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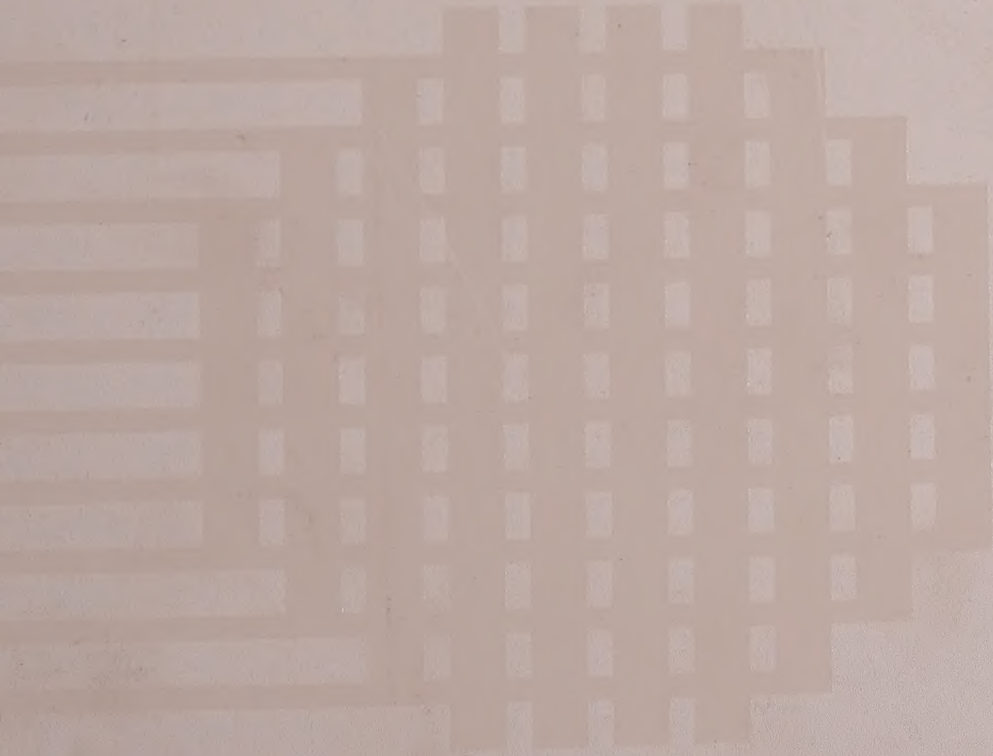

KEITHLEY

Model 7001
Switch System
Instruction Manual

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Model 7001 Switch System

Instruction Manual

KEITHLEY
SELECT CHANNELS
7001 SWITCH SYSTEM
INFO
LOCAL
POWER
OPEN ALL
STEP
OPEN
CLOSE
MEMORY
CONFIGURATION
SCAN LIST
STORE
SCAN
CARD
DELETE
INSERT
CLEAR LIST
RECALL
MENU
EXIT
ENTER

Contains Operating and Servicing Information

KEITHLEY

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10/99

Model 7001 Switch System Instruction Manual

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Document Number 7001-901-01 Rev. G

Card Installation
Getting Started
Front Panel Operation
Common Commands
SCPI Command Subsystems
Servicing Information

Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

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Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Users of this product must be protected from electric shock at all times. The responsible body must ensure that users are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product users in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

As described in the International Electrotechnical Commission (IEC) Standard IEC 664, digital multimeter measuring circuits (e.g., Keithley Models 175A, 199, 2000, 2001, 2002, and 2010) are Installation Category II. All other instruments' signal terminals are Installation Category I and must not be connected to mains.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

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The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a ⏚ screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The ⚠ symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The ⚡ symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

Rev. 10/99

MODEL 7001 SWITCHING MAINFRAME

SYSTEM

CAPACITY: Two plug-in cards per mainframe.

MEMORY: Battery backed-up storage for 100 switch patterns.

SWITCH SETTLING TIME: Automatically selected by the mainframe for each card. Additional time from 0 to 99999.999 seconds can be added in 1ms increments.

TRIGGER SOURCES:

External Trigger (TTL-compatible, programmable edge, 600 ns minimum pulse, rear panel BNC).

IEEE-488 bus (GET, *TRG)

Trigger Link

Manual (front panel)

Internal Timer, programmable from 1ms to 99999.999 seconds in 1ms increments.

STATUS OUTPUT: Channel Ready (TTL-compatible signal, rear panel BNC). Low going pulse (10µs typical) issued after relay settling time. For two different switch cards, 7001 will be set to the slowest relay settling time.

SWITCHING SEQUENCE: Automatic break-before-make.

MAINFRAME DIGITAL I/O: 4 Open collector outputs (30V maximum pull up voltage, 100mA maximum sink current, 10Ω output impedance), 1 TTL compatible input, 1 common.

RELAY DRIVE: 700mA maximum for both card slots.

CARD SIZE: 32mm high × 114mm wide × 272mm long (1.25 in. × 4.5 in. × 10.75 in.).

CARD COMPATIBILITY: Fully compatible with all 705, 706, and 7XXX cards.

THROUGHPUT

EXECUTION SPEED OF SCAN LIST: [1]

	7011 Card	7015 Card
Individual channels:	130/second	500/second
Memory setups:	125/second	450/second

TRIGGER EXECUTION TIME (maximum time from activation of Trigger Source to start of switch open or close[2]):

SOURCE	LATENCY	JITTER
GET[3]	200 µs	< 50 µs
*TRG[3]	5.0 ms	
Trigger Link	200 µs	< 13 µs
External	200 µs	< 13 µs

[1] Rates include switch settling time of cards: 3ms for 7011 and 500µs for 7015 card.

[2] Excludes switch settling time.

[3] Assuming no IEEE-488 commands are pending execution.

IEEE-488 COMMAND EXECUTION TIME

	EXECUTION TIME[1]	
COMMAND	DISPLAY OFF	DISPLAY ON
OPEN (@1!1)	7.5 ms	8.5 ms
CLOS (@1!1)	7.5 ms	8.5 ms
MEM:REC M1	5.0 ms	6.0 ms

[1] Measured from the time at which the command terminator is taken from the bus to the time at which the relay begins to open or close.

ANALOG BACKPLANE

SIGNALS: Four 3-pole rows (Hi, Lo, Guard). These signals provide matrix and multiplexer expansion between cards within one mainframe.

MAXIMUM VOLTAGE: 250V DC, 250V RMS, 350V AC peak, signal path to signal path or signal path to chassis.

MAXIMUM CURRENT: 1 A peak.

PATH ISOLATION:

$>10^{10}\Omega$, <50 pF path to path (any Hi, Lo, Guard to another Hi, Lo, Guard).

$>10^{10}\Omega$, <50 pF differential (Hi to Lo or Hi, Lo to Guard).

$>10^{9}\Omega$, <75 pF path to chassis.

CHANNEL CROSSTALK: < -65 dB @ 1 MHz (50 ohm load).

BANDWIDTH: < 3 dB loss at 100 MHz (50 ohm load).

IEEE-488 BUS

STANDARDS CONFORMANCE: Conforms to SCPI-1990, IEEE 488.2 and IEEE 488.1.

MULTILINE COMMANDS: DCL, LLO, SDC, GET, GTL, UNT, UNL, SPE, SPD.

UNILINE COMMANDS: IFC, REN, EOI, SRQ, ATN.

INTERFACE FUNCTIONS: SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.

GENERAL

DISPLAY:

Dual line vacuum fluorescent.

1st line: 20-character alphanumeric.

2nd line: 32-character alphanumeric.

REAR PANEL CONNECTORS:

IEEE-488

8-pin micro DIN connector for digital I/O

8-pin micro DIN for Trigger Link

8-pin micro DIN for Trigger Link expansion

BNC for External Trigger

BNC for Channel Ready

POWER: 90-260VAC universal input, 47-440 Hz, 40VA maximum.

SAFETY: Designed to meet UL 1244, IEC 348.

EMI/RFI: Meets VDE 0871B and FCC Class B.

ENVIRONMENT:

Operating: 0°C to 50°C, <80% relative humidity (0°C to 35°C).

Storage: -25°C to +65°C.

DIMENSIONS, WEIGHT: H 89mm, W 216mm, L 375mm, 3.4kg (H 3.5", W 8.5", L 14.8", 7.5lb).

Specifications subject to change without notice.

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1

General Information

1.1 Introduction

This section contains general information about the Model 7001 Switch System.

1.2 Features
1.3 Warranty Information
1.4 Manual Addenda
1.5 Safety Symbols and Terms
1.6 Specifications
1.7 Inspection
1.8 Optional Accessories

1.2 Features

Some important Model 7001 features include:

- High Density Switching — Up to 80 channels per mainframe using two switching cards.
- Switching Cards — In addition to the switching cards designed specifically for the Model 7001 (i.e. Models 7011, 7012 and 7013), you can use the switching cards that were originally designed for the Keithley Models 705 and 706 scanners.
- Analog Backplane — Can be used to internally connect the rows or banks of a Model 701X series card installed in one slot to the rows or banks of a second Model 701X series card installed in the other slot.
- Close/Open or Scan — The Model 7001 can simply close and/or open one or more channels, or scan through a specified list of channels.
- Channel Status Display — The real-time status display monitors the state (closed or open) of all available channels.
- Memory — Up to 100 channel patterns (pattern of open and closed channels) and 10 customized instrument setups can be saved in memory for later recall.
- IEEE-488 Bus — Bus operation conforms to the IEEE-488.2 and SCPI standards.
- Trigger Link — New trigger concept to provide more versatile and precise external triggering. This is in addition to the standard in/out BNC external triggering technique.

1.3 Warranty information

Warranty information is located on the inside front cover of this instruction manual. Should your Model 7001 require warranty service, contact the Keithley representative or authorized repair facility in your area for further information. When returning the instrument for repair, be sure to fill out and include the service

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form at the back of this manual in order to provide the repair facility with the necessary information.

1.4 Manual addenda

Any improvements or changes concerning the instrument or manual will be explained in an addendum included with the manual. Be sure to note these changes and incorporate them into the manual.

1.5 Safety symbols and terms

The following symbols and terms may be found on an instrument or used in this manual.

The symbol ⚠ on an instrument indicates that the user should refer to the operating instructions located in the instruction manual.

The symbol ⚡ on an instrument shows that high voltage may be present on the terminal(s). Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading used in this manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading used in this manual explains hazards that could damage the scanner card. Such damage may invalidate the warranty.

1.6 Specifications

Model 7001 specifications may be found at the front of this manual.

1.7 Inspection

The Model 7001 was carefully inspected, both electrically and mechanically before shipment. After unpacking all items from the shipping carton, check for any obvious signs of physical damage that may have occurred during transit. Report any damage to the shipping agent immediately. Save the original packing carton for possible future reshipment. The following items are included with every Model 7001 order:

- Model 7001 Switch System
- Model 7001 Instruction Manual
- Accessories as ordered.

If an additional instruction manual is required, order the manual package, Keithley part number 7001-901-00. The manual package includes an instruction manual and any pertinent addenda.

1.8 Optional accessories

The following accessories are available from Keithley for use with the Model 7001.

Model 4288-1 Single Fixed Rack Mount Kit; mounts a single Model 7001 in a standard 19-inch rack.

Model 4288-2 Dual Fixed Rack Mount Kit; mounts two Model 7001s side-by-side in a standard 19-inch rack.

Model 4288-3 Dual Fixed Rack Mount Kit; mounts one Model 7001 and a Model 199 DMM side-by-side in a standard 19-inch rack.

Model 8502 Trigger Link Adapter; allows you to connect the Trigger Link of the Model 7001 to an instrument that uses the standard BNC (In/Out) external triggering technique.

Models 8501-1 and 8501-2 Trigger Link Cables: The Model 8501-1 is one meter in length, and the Model 8501-2 is two meters in length.

Model 7007 Shielded IEEE-488 Cables: Connects the Model 7001 to the IEEE-488 bus using shielded cables to reduce electromagnetic interference (EMI). The Model 7007-1 is one meter in length and has an EMI shielded IEEE-488 connector at each end. The Model 7007-2 is identical to the Model 7007-1, but is two meters in length.

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2

Card Installation

ATTENTION FIRST TIME USERS

If you are a first time user, it is recommended that you perform the operation demo in Section 3, Getting Started (paragraph 3.3) before installing any switching cards into the mainframe. This demo will acquaint you with basic front panel operation.

WARNING

The procedures in this section are intended for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Failure to recognize and observe normal safety precautions could result in personal injury or death.

2.1 Introduction

The Model 7001 is designed to be used with the Model 701X series switch cards (i.e. Model 7011, 7012, and 7013), and with cards that were originally designed to be used with the Keithley Model 705/706 scanners.

Installation procedures in this section are organized as follows:

2.2 **Model 701X series card installation:** Explains how to install a Model 701X series card (such as the Model 7011, 7012, or 7013) card in the Model 7001.

2.3 **Non-701X series card installation:** Explains how to install cards designed for the Model 705/706 scanner in the Model 7001.

2.2 Model 701X series card installation

WARNING

Turn off power from all instrumentation (including the Model 7001 mainframe) and disconnect their line cords. Make sure all power is removed and stored energy in external circuitry is discharged.

NOTE

If using the screw terminal connector card, make sure your external circuitry is wired to the card (as explained in the instruction manual for the card) before installing the card assembly in the Model 7001 mainframe.

CAUTION

To prevent contamination to the switch card that could degrade performance, only handle the card assembly by the edges and shields. If contamination occurs, clean the card as explained in its instruction manual.

Card installation

Perform the following steps to install the card assembly in the Model 7001 mainframe:

1. Mate the connector card to the relay card if they are separate. Make sure to handle the cards by the edges and shields to prevent contamination.
2. Facing the rear panel of the Model 7001, select the slot (CARD 1 or CARD 2) that you wish to install the card in.
3. Referring to Figure 2-1 or Figure 2-2, feed the card assembly into the desired slot such that the edges of the relay card ride in the rails.
4. With the ejector arms in the unlocked position, push the card assembly into the mainframe until the arms engage into the ejector cups. Then push both arms inward to lock the card all the way into mainframe.
5. For the multi-pin connector card, install the screw shown in Figure 2-1.

Notes:

1. Once a Model 701X series card is installed in the mainframe, the Model 7001 automatically identifies it on power up. This ID allows the Model 7001 to configure itself for proper operation.
2. When a Model 701X series card is installed, the slot assignment (Card TYPE) is performed automatically on power-up. A slot assignment change could make a channel that is currently included in the Scan List and/or a Channel Pattern unavailable. The unavailable channel causes the Scan List and/or the affected Channel Pattern to clear (see paragraph 4.5.2 and 4.5.5 for details).

Card removal

To remove the card assembly, first unlock it by pulling the ejector arms outward, then pull the card assembly out of the mainframe. Remember to handle the card assembly by the edges and shields to avoid contamination that could degrade performance.

2.3 Non-701X series cards

WARNING

Turn off power from all instrumentation (including the Model 7001 mainframe) and disconnect their line cords. Make sure all power is removed and stored energy in external circuitry is discharged.

NOTE

If using a card that requires connections to be made on the card, make sure your external circuitry is wired to the card (as explained in the instruction manual for the card) before installing the card in the Model 7001 mainframe.

CAUTION

To prevent contamination to the switch card that could degrade performance, only handle the card by the edges. If contamination occurs, clean the card as explained in its instruction manual.

Card installation

Perform the following steps to install the card in the Model 7001 mainframe:

1. Facing the rear panel of the Model 7001, select the slot (CARD 1 or CARD 2) that you wish to install the card in.
2. Using Figure 2-1 or Figure 2-2 as a guideline, feed the card into the desired slot such that the edges of the card ride in the rails.
3. With the ejector arms in the unlocked position, push the card assembly into the mainframe until the arms engage into the ejector cups. Then push both arms inward to lock the card into the mainframe.

NOTE

The Model 7001 cannot automatically identify non-701X cards. After the mainframe is powered up, you must enter the model number using the TYPE menu item in the CARD CONFIG MENU (see paragraph 3.5.3 in Getting Started).

Card removal

To remove the card, first unlock it by pulling the ejector arms outward, then pull the card out of the mainframe. Remember to handle the card by the edges to avoid contamination that could degrade performance.

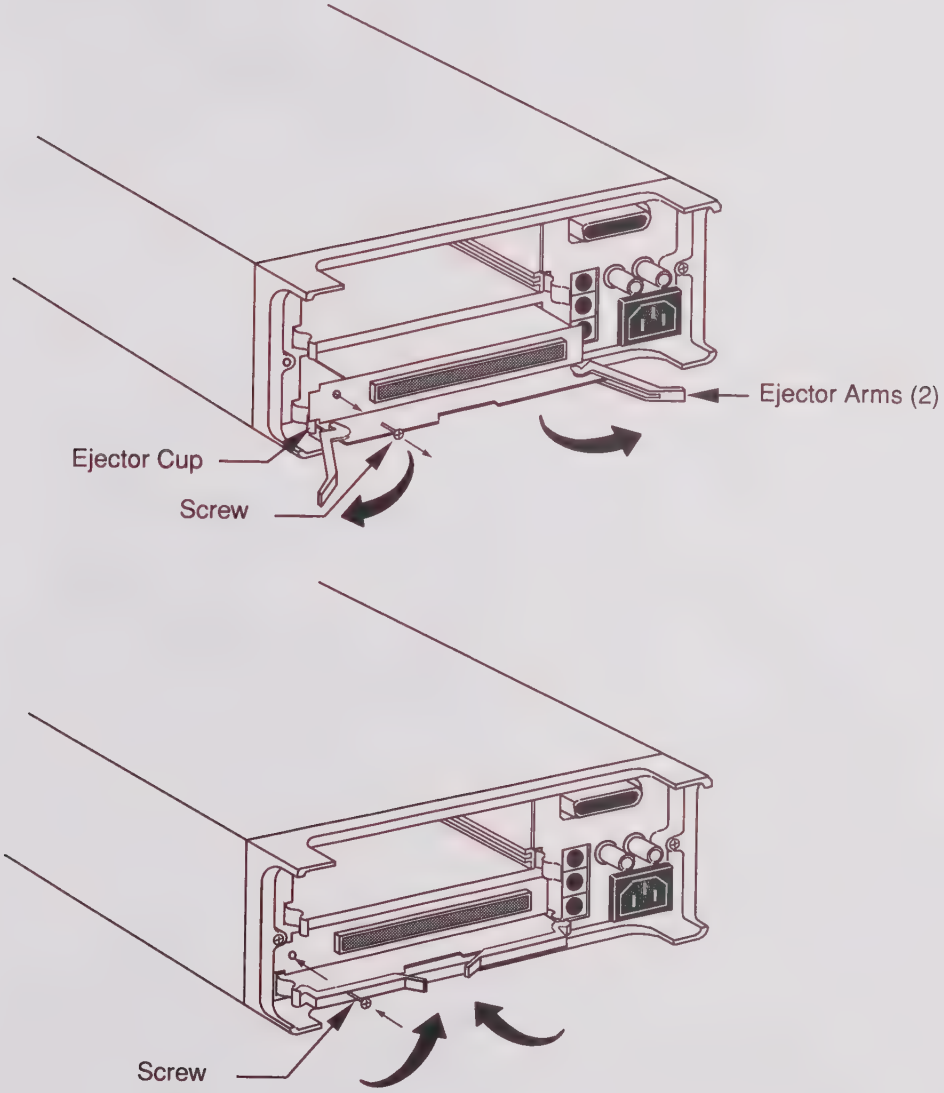

Figure 2-1
Multi-pin card installation

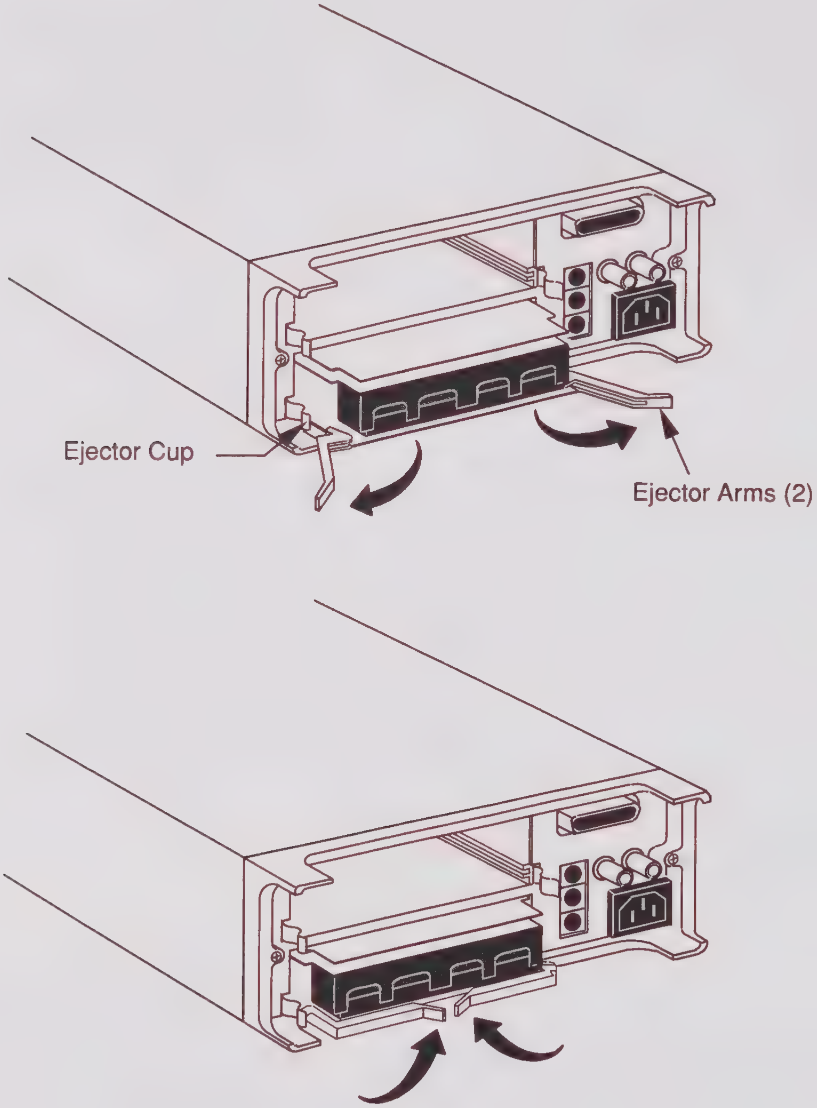
Ejector Cup
Ejector Arms (2)

Figure 2-2
Screw terminal card installation

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Operation

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Commands

SCPI Command
Subsystems

Servicing
Information

3

Getting Started

3.1 Introduction

This section contains introductory information on using your Model 7001 Switch System. For detailed front panel and IEEE-488 bus operation, refer to Sections 4 and 5 respectively.

The information in this section is arranged as follows:

3.2 **Front and rear panel configuration:** Summarizes the controls and display on the front panel of the instrument.

3.3 **Operation demo:** Demonstrates basic operation using the built-in 40-channel multiplexer simulator. Recommended for first time users.

3.4 **Overview of scan process:** Provides a brief overview of the scan process.

3.5 **Initial configuration:** Goes over some initial configuration information that should be considered before operating the instrument.

3.6 **Front panel operation:** Demonstrates basic front panel operation through the use of simple examples.

3.7 **IEEE-488.2 and SCPI basics:** Discusses fundamental information concerning operation over the IEEE-488 bus.

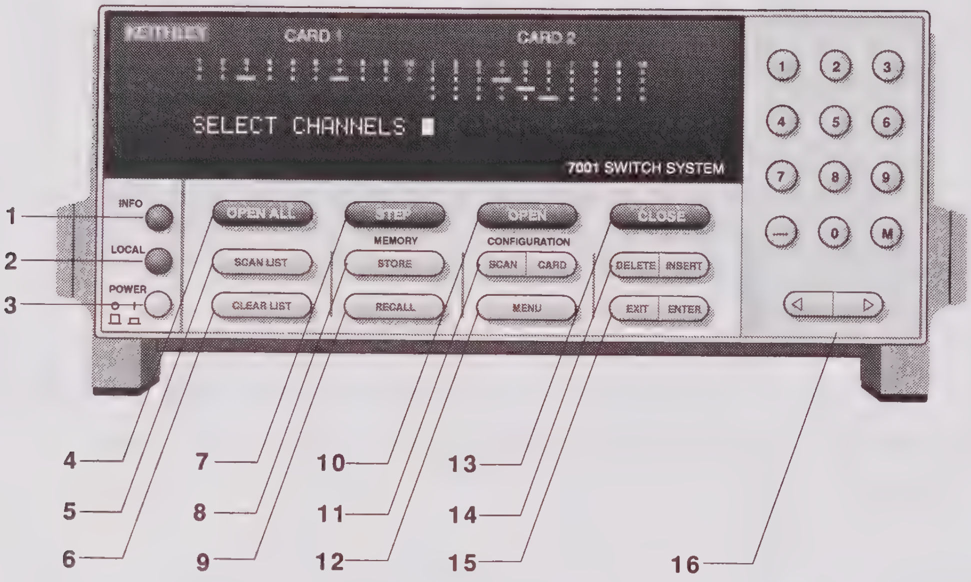
3.2 Front and rear panel configurations

3.2.1 Front panel controls

The front panel controls of the Model 7001 are shown in Figure 3-1. This figure includes important abbreviated information that should be reviewed before operating the instrument. Notice that some of the controls are dual-function, rocker-action type keys. These include SCAN/CARD CONFIGURATION, DELETE/INSERT, EXIT/ENTER and ◁ / ▷ .

3.2.2 Rear panel

The rear panel of the Model 7001 is shown in Figure 3-2. This figure also includes important abbreviated information that should be reviewed before operating the instrument.


KEITHLEY
CARD 1
CARD 2
SELECT CHANNELS
7001 SWITCH SYSTEM
INFO
LOCAL
POWER
OPEN ALL
SCAN LIST
CLEAR LIST
STEP
MEMORY
STORE
RECALL
OPEN
CONFIGURATION
SCAN
CARD
MENU
CLOSE
DELETE
INSERT
EXIT
ENTER
1
2
3
4
5
6
7
8
9
—
0
M
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

1 INFO
Displays on-line help information. Press again (or EXIT) to cancel message.

2 LOCAL
Cancels remote, restores front panel control.

3 POWER
0 =off
1 = on

4 OPEN ALL
Opens all channels of both slots. Also, aborts a scan that is in progress and places 7001 in idle state.

5 SCAN LIST
Toggles between Scan List and Channel List

6 CLEAR LIST
Clears the displayed Channel List or Scan List.

7 STEP
Takes 7001 out of idle state and steps through Scan List

8 STORE
Stores channel pattern at a specified memory location.

9 RECALL
Restores 7001 to a channel pattern stored at a specified memory location.

10 OPEN
Opens the specified (displayed) channels in Channel List.

11 SCAN CONFIGURATION
Enables CONFIGURE SCAN MENU :
CHAN-CONTROL
SCAN-CONTROL
ARM-CONTROL
CHAN-RESTRICTIONS

CARD CONFIGURATION
Enables CARD CONFIG MENU :
TYPE
#-OF-POLES
CARD-PAIR
DELAY
READ-I/O-CARD

12 MENU
Enables MAIN MENU:
SAVESETUP
GPIB
DIGITAL-I/O
TEST
LANGUAGE
GENERAL

13 CLOSE
Closes the specified (displayed) channels in Channel List.

14 DELETE
Delete selected entry from Channel List or Scan List.

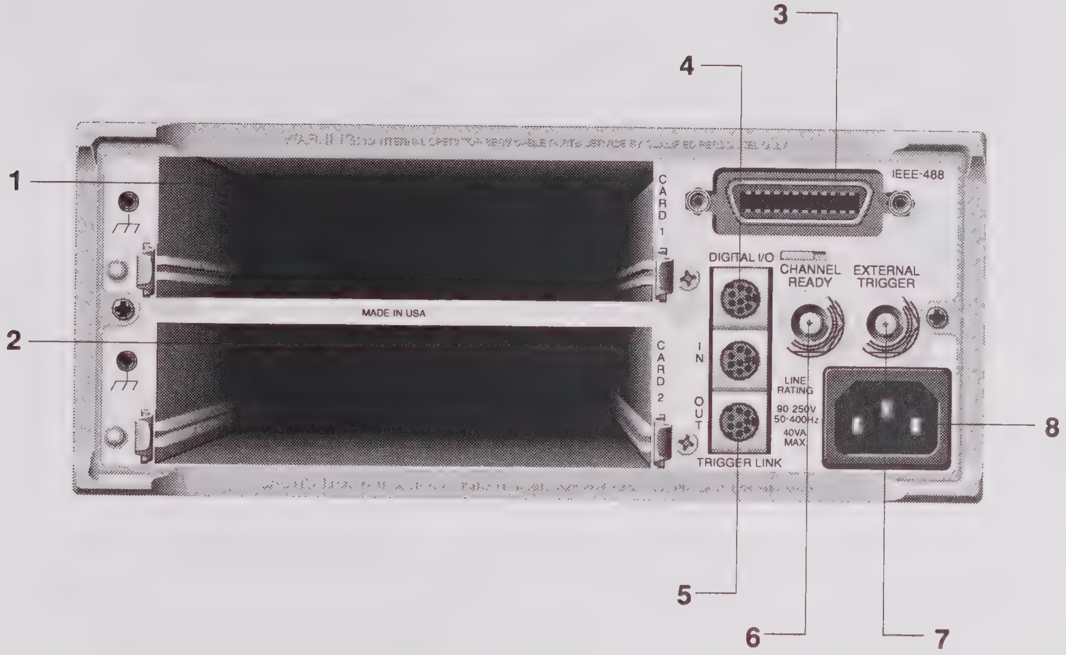
INSERT
Insert next entry at selected location in the Channel List or Scan List.

15 EXIT
Back up to previous menu selection, or exit from the menu.

ENTER
Execute the pending operation. Also, separate channels and terminate a Channel List or Scan List.

16 KEYPAD
0 - 9; use to enter numbers.
- ; use to specify a range of channels (i.e. 1!1 - 1!40).
M ; use to precede a specified memory location number.
◁ ; use to move cursor left or
▷ ; use to move cursor right. Also, use to separate channels and terminate a Channel List on Scan List.

Figure 3-1
Model 7001 front panel


3
4
1
2
8
5
6
7
CARD 1
CARD 2
IEEE-488
DIGITAL I/O
CHANNEL READY
EXTERNAL TRIGGER
MADE IN USA
IN
OUT
LINE RATING
90-250V
50-400Hz
40VA MAX
TRIGGER LINK

1 **CARD 1**
Slot 1 for swich card. Corresponds to Card 1 channel status display.

2 **CARD 2**
Slot 2 for switch card. Corresponds to Card 2 channel status display.

3 **IEEE-488 CONNECTOR**
Use standard IEEE-488 cables.

4 **DIGITAL I/O**
Micro 8-pin DIN connector. Port consists of four TTL output lines and one TTL input line (one common line).

5 **TRIGGER LINK IN AND OUT**
Two micro 8-pin DIN connectors.

6 **CHANNEL READY**
Female BNC connector for TTL output trigger pulse.

7 **EXTERNAL TRIGGER**
Female BNC connector for TTL input trigger pulse.

8 **LINE POWER INPUT**
WARNING: Connect to grounded outlet using three-wire power cord.

Figure 3-2
Model 7001 rear panel

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3.2.3 Channel status display

The channel status display provides real-time status of each available channel for the two slots. Only the available channels are displayed. There are two channel status display modes; the Channel List entry mode (SELECT CHANNELS) and the Scan List entry mode (SCAN CHANNELS). On power-up, the Channel List entry mode is selected. The SCAN LIST key toggles between the Channel List and the Scan List. The instrument can be returned to the channel status display by pressing the EXIT key one or more times.

The channel status display is shown in Figure 3-3. This display is structured as two 10-column grids. The left grid provides the channel status of the card installed in slot 1 (CARD 1) and the right grid provides the channel status of the card installed in slot 2 (CARD 2). As shown in the illustration, an open channel is represented as a "dot" while a closed channel is represented as a "dash".

Channel assignments — The channel assignment format is automatically determined by the card type. There is a three-integer format to express matrix card channels, and a two-integer format to express channels for all other types of switching cards. The individual integers that make up the channel assignment are separated by an exclamation point (!).

> **Matrix cards:** Matrix cards use the three-integer format to express channel assignments. The first integer designates the slot number that the card is installed in. Thus, a "1" designates slot 1 (CARD 1), and a "2" designates slot 2 (CARD 2). The second integer designates the row number of the matrix card. There are four rows; the top row is Row 1, the second row from the top is Row 2, the next row is Row 3, and the bottom row is Row 4. The third integer designates the column of the matrix card. The 10 matrix columns are displayed by the channel status display. The assignments for all matrix card channels are presented in Figure 3-4.

If, for example, CARD 1 in Figure 3-3 happened to be a Model 7012 matrix card, the following channels would be closed:

Channel 1!2!3 (Slot 1, Row 2, Column 3)

Channel 1!4!9 (Slot 1, Row 4, Column 9)

All other card types: All non-matrix type switching cards use the two-integer format to express channel assignments. The first integer, like the matrix card, designates the slot number. The second integer designates switch card channel number. The channel assignments for these card types are presented in Figure 3-5.

If, for example, CARD 2 in Figure 3-3 happened to be a Model 7011 multiplexer card, the following channels would be closed:

Channel 2!14 (Slot 2, Channel 14)

Channel 2!36 (Slot 2, Channel 36)

For the Model 7011 multiplexer card, Channel 14 corresponds to Bank 1, Relay 4, and Channel 36 corresponds to Bank 3, Relay 6. See the Model 7011 instruction manual for details.

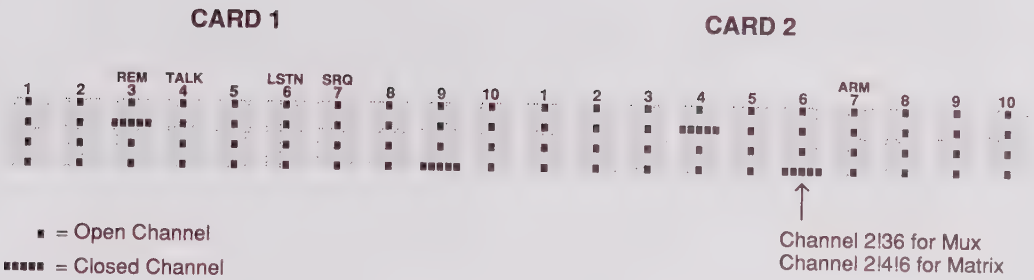
CARD 1
CARD 2
1
2
REM 3
TALK 4
5
LSTN 6
SRQ 7
8
9
10
1
2
3
4
5
6
ARM 7
8
9
10
▪ = Open Channel
▪▪▪▪▪ = Closed Channel
Channel 2!36 for Mux
Channel 2!4!6 for Matrix

Figure 3-3
Channel status display

1	2	3	4	5	6	7	8	9	10
1!1!1	1!1!2	1!1!3	1!1!4	1!1!5	1!1!6	1!1!7	1!1!8	1!1!9	1!1!10
1!2!1	1!2!2	1!2!3	1!2!4	1!2!5	1!2!6	1!2!7	1!2!8	1!2!9	1!2!10
1!3!1	1!3!2	1!3!3	1!3!4	1!3!5	1!3!6	1!3!7	1!3!8	1!3!9	1!3!10
1!4!1	1!4!2	1!4!3	1!4!4	1!4!5	1!4!6	1!4!7	1!4!8	1!4!9	1!4!10

A. Slot 1 (Card 1)

1	2	3	4	5	6	7	8	9	10
2!1!1	2!1!2	2!1!3	2!1!4	2!1!5	2!1!6	2!1!7	2!1!8	2!1!9	2!1!10
2!2!1	2!2!2	2!2!3	2!2!4	2!2!5	2!2!6	2!2!7	2!2!8	2!2!9	2!2!10
2!3!1	2!3!2	2!3!3	2!3!4	2!3!5	2!3!6	2!3!7	2!3!8	2!3!9	2!3!10
2!4!1	2!4!2	2!4!3	2!4!4	2!4!5	2!4!6	2!4!7	2!4!8	2!4!9	2!4!10

B. Slot 2 (Card 2)

Exampels : 1!2!4 = Slot 1, Row 2, Column 4
2!3!6 = Slot 2, Row 3, Column 6

Figure 3-4
Channel assignments (matrix cards)

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1	2	3	4	5	6	7	8	9	10
1!1	1!2	1!3	1!4	1!5	1!6	1!7	1!8	1!9	1!10
1!11	1!12	1!13	1!14	1!15	1!16	1!17	1!18	1!19	1!20
1!21	1!22	1!23	1!24	1!25	1!26	1!27	1!28	1!29	1!30
1!31	1!32	1!33	1!34	1!35	1!36	1!37	1!38	1!39	1!40

A. Slot 1 (Card 1)

1	2	3	4	5	6	7	8	9	10
2!1	2!2	2!3	2!4	2!5	2!6	2!7	2!8	2!9	2!10
2!11	2!12	2!13	2!14	2!15	2!16	2!17	2!18	2!19	2!20
2!21	2!22	2!23	2!24	2!25	2!26	2!27	2!28	2!29	2!30
2!31	2!32	2!33	2!34	2!35	2!36	2!37	2!38	2!39	2!40

B. Slot 2 (Card 2)

Exampels : 1!18 = Slot 1, Channel 18
2!36 = Slot 2, Channel 36

Figure 3-5
Channel assignments (non-matrix type cards)

3.3 Operation demo

A fast and easy way to acquaint yourself with basic front panel operation is to use the following operation demo. This demo uses the built-in 40-channel multiplexer simulator. This will allow you to simulate operation without the need of a switching card.

3.3.1 Initial configuration

WARNING

Before turning the Model 7001 on, make sure it is connected to a grounded power receptacle using the supplied power cord or the equivalent. Failure to properly ground the unit creates a shock hazard that could result in injury or death.

Step 1 of the following procedure will RESET the Model 7001 to a default scan configuration that is required for the demonstration procedures (paragraphs 3.3.2 and 3.3.3). Step 2 will assign the 40-channel multiplexer simulator to slot 2.

Step 1. RESET instrument

1. Press the MENU key. The MAIN MENU will be displayed.
2. Place the cursor on SAVESETUP using the ◁ and ▷ cursor keys, and press the ENTER key. The SETUP MENU will be displayed.
3. Place the cursor on RESET and press ENTER. The "RESETTING INSTRUMENT" message will be displayed.
4. Press ENTER again. The "RESET COMPLETE" message will be displayed.
5. Press ENTER to return the display to the SETUP MENU.
6. Press EXIT twice to exit from the MAIN MENU.

Step 2. select multiplexer simulator

NOTE

The simulator cannot be selected if there is a Model 701X series card installed in slot 2.

1. Press the CARD CONFIGURATION key. The CARD CONFIG MENU will be displayed.
2. Place the cursor on TYPE and press ENTER. The SET CARD TYPE menu will be displayed.
3. Place the cursor on SLOT-2 and press ENTER. The "SLOT-2 CARD: XXXX" message will be displayed (where XXXX is the current card assignment for slot 2).
4. Use the cursor keys to display model number "9990".
5. With "SLOT-2 CARD: 9990" displayed, press ENTER. The SET CARD TYPE menu will be displayed.
6. Press EXIT twice to exit from the CARD CONFIG MENU.

3.3.2 Close and open channels

The following procedures assume that the initial configuration procedure in paragraph 3.3.1 has been performed. This initialization will assign the 40-channel multiplexer simulator to Slot 2 for the following operating examples.

NOTE

The Model 7001 must be in the Channel List display mode ("SELECT CHANNELS" prompt displayed). The SCAN LIST key toggles the channel status display between "SELECT CHANNELS" (Channel List) and "SCAN CHANNELS" (Scan List). If the instrument is not in the channel status display mode, press EXIT until it is.

Create Channel List:

The Channel List specifies which channels you wish to close and open. The Channel List can be made up of a single channel, or multiple channels. Consecutive channels can be specified as a range.

The following procedure will create a Channel List that includes Channels 1, 2, and 6 through 9:

1. If the Channel List is not currently empty, press CLEAR LIST. The following message indicates an empty Channel List:

   ```
   SELECT CHANNELS
   ```

2. Individual Channel Entry - Perform the following steps to enter Channels 1 and 2 in the Channel List:

   A. Press "2" and then "1" to enter Channel 1 into the Channel List. The "2" selects slot 2.

   ```
   SELECT CHANNELS 2!1
   ```

   B. Press ▷ or ENTER to enter the channel separator (,).

   ```
   SELECT CHANNELS 2!1,
   ```

   C. Press "2" and then "2" to enter channel 2, and then press ▷ or ENTER to enter the channel separator (,).

   ```
   SELECT CHANNELS 2!1, 2!2,
   ```

3. Range Entry - Perform the following steps to enter Channels 6 through 9 as a range:

   A. Press "2" and then "6" to enter the range limit (Channel 6).

   ```
   SELECT CHANNELS 2!1, 2!2, 2!6
   ```

   B. Press "-" to enter the range separator. Note that the slot number for the next channel is automatically entered.

   ```
   SELECT CHANNELS 2!1, 2!2, 2!6-2!
   ```

   C. Press "9" to enter the range limit.

   ```
   SELECT CHANNELS 2!1, 2!2, 2!6-2!9
   ```

Close and open channels

1. Press CLOSE to close the channels specified in the Channel List.
2. Press OPEN to open the channels specified in the Channel List. Note that OPEN ALL opens all channels (even those not specified in the Channel List).

3.3.3 Scan channels

The following procedures assume that the initial configuration procedure in paragraph 3.3.1 has been performed. This initialization will assign the 40-channel multiplexer simulator to Slot 2 for the following scan examples.

NOTE

The Model 7001 must be in the Scan List display mode ("SCAN CHANNELS" prompt displayed). The SCAN LIST key toggles the channel status display between "SELECT CHANNELS" (Channel List) and "SCAN CHANNELS" (Scan List). If the instrument is not in the channel status display mode, press EXIT until it is.

Create scan list

Perform the following steps to create a scan list that will scan channels 1 through 20:

1. If the Scan List is not currently empty, press CLEAR LIST. The following message indicates an empty Scan List:

   ```
   SCAN CHANNELS
   ```

2. Press "2" and then "1" to enter the slot and the range limit.

   ```
   SCAN CHANNELS 2!1
   ```

3. Press "-" to enter the separator for the range limits. Notice that the slot number for the next channel will automatically be entered.

   ```
   SCAN CHANNELS 2!1-2!
   ```

4. Press "2" and then "0" to enter the limit of the range.

   ```
   SCAN CHANNELS 2!1-2!20
   ```

5. Press ▷ or ENTER to enter the scan list terminator (,).

   ```
   SCAN CHANNELS 2!1-2!20,
   ```

Note: Instead of specifying the 20 channels in the scan list as a range, they could have been entered individually (2!1, 2!2, 2!3, ... 2!20,).

Manual scan

The RESET defaults configure the instrument to manually scan an infinite number of channels. After the 20th channel is scanned, operation will wrap around to the beginning of the scan list (Channel 1).

1. Press STEP to take the Model 7001 out of the idle state. The ARM indicator will turn on.
2. Press the STEP key to scan the first channel. This channel will remain closed until another channel is scanned.
3. Press the STEP key to scan the second channel. The first channel will open and the second channel will close.
4. Each press of the STEP key will open the previous channel and close the next channel (break-before-make).
5. When finished, press OPEN ALL to abort the scan and open all channels. The instrument goes into the idle state (ARM indicator turns off).

Automatic scan

Perform the following steps to automate the 20-channel scan. A 0.5 second delay will be used between each channel.

1. Press OPEN ALL if there are any channels closed or the ARM indicator is on
2. Press the SCAN CONFIGURATION key. The CONFIGURE SCAN menu will be displayed.

NOTE

Due to space limitations, not all menu selections can be displayed on the Model 7001 at the same time. A displayed arrow (◀ or ▶) indicates that there are additional menu selections to choose from. Use the ◁ and ▷ cursor keys to display them.

3. Using the ◁ and ▷ keys, place the cursor on CHAN-CONTROL and press ENTER. The CHANNEL CONTROL menu will be displayed.
4. Place the cursor on CHANNEL-SPACING and press ENTER. The SELECT CHAN SPACING menu will be displayed.

```
SELECT CHAN SPACING
TRIGLINK   IMMEDIATE   HOLD
```

5. Place the cursor on IMMEDIATE and press ENTER. The display will return to the CHANNEL CONTROL menu.
6. Press EXIT twice to exit from the CONFIGURE SCAN menu and return to the channel status display.
7. Press CARD CONFIGURATION. The CARD CONFIG MENU will be displayed.

```
CARD CONFIG MENU
DELAY   READ-I/O-CARD
```

8. Place the cursor on DELAY and press ENTER. The SET DELAY FOR: menu will be displayed.
9. Place the cursor on SLOT-2 and press ENTER. The delay period (in seconds) will be displayed.

```
(2)DELAY = 00000.000
```

10. Use the keypad to set the delay for 0.5 seconds.

```
(2)DELAY = 00000.500
```

This delay will occur after each channel closes.

11. Press ENTER. The display will return to the SET DELAY FOR: menu.
12. Press EXIT twice to return to the channel status display.
13. To start the scan, simply press STEP. The instrument leaves the idle state (ARM indicator on) and immediately closes the first channel. After a 0.5 second delay the first channel will open and the second channel will close. This automatic scan will continue at the 0.5 second scan rate.
14. When finished, press OPEN ALL.

TIMER controlled scans

An internal timer can be used to control the time interval between the scans. The 20-channel scan will be modified by using a TIMER to place a 20-second interval between the start of each scan.

1. Press OPEN ALL to ensure that the instrument is in the idle state.
2. Press SCAN CONFIGURATION. The CONFIGURE SCAN menu will be displayed.
3. Place the cursor on SCAN-CONTROL and press ENTER. The SCAN CONTROL menu will be displayed.
4. Place the cursor on SCAN-SPACING and press ENTER. The SELECT SCAN SPACING menu will be displayed.

```
SELECT SCAN SPACING
TIMER   EXTERNAL   GPIB   MANUAL
```

5. Place the cursor on TIMER and press ENTER. The timer interval (in seconds) will be displayed.

```
INTERVAL = 00000.001
```

6. Use the keypad to key in an interval of 20 seconds.

```
INTERVAL = 00020.000
```

7. Press ENTER. The display will return to the SCAN CONTROL menu.
8. Press EXIT twice to exit from the CONFIGURE SCAN menu and return to the channel status display.
9. To start the scan, press STEP. The first scan will start immediately and stop after the 20th channel closes. After 10 additional seconds expires (20 seconds after the start of the scan), the next scan will start.
10. When finished, press OPEN ALL.

3.4 Overview of scan process

The following overview is intended to acquaint you with the basic scan fundamentals without overwhelming you with the details of enhanced capabilities. This brief overview is sufficient to support the operation examples in paragraphs 3.5 (front panel) and 3.6 (IEEE-488 bus). For a complete explanation on all aspects of the scan process, see paragraph 4.5.4.

The simplified model for scan operation is shown in Figure 3-6. As shown, scan operation consists of three layers; the arm layer, scan layer and channel layer.

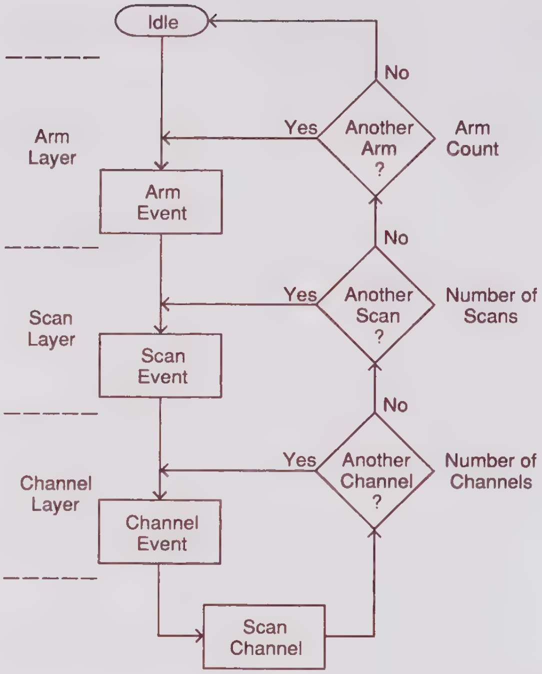

Figure 3-6
Simplified model of scan operation

Idle

The instrument is considered to be in the idle state whenever it is not operating within one of the layers of the model. The front panel ARM indicator is off when the instrument is in the idle state.

When the Model 7001 is taken out of the idle state by pressing STEP (or sending the :INIT or :INIT:CONT ON command over the IEEE-488 bus), the ARM indicator turns on and operation proceeds into the arm layer.

Arm layer

In general, the instrument requires an arm event to allow operation to proceed to the scan layer. With Immediate arm spacing selected, operation immediately proceeds to the next layer when the instrument is taken out of the idle state. With one of the other arm spacing events selected, the instrument will wait until the appropriate event occurs.

With Manual arm spacing selected, the instrument will wait until the front panel STEP key is pressed. With GPIB arm spacing selected, the instrument will wait until a bus trigger (GET or *TRG) is received. With External arm spacing selected, the instrument will wait until an input trigger (via EXTERNAL TRIGGER connector on rear panel) is received. With Trigger Link arm spacing selected, the instrument will wait until an input trigger is received (via TRIGGER LINK).

After all other scanning operations are completed, the instrument can be returned to the arm layer by programming the instrument for additional arms. The arm count can be set to a finite value (1 to 9999) or to infinity.

After the instrument leaves the arm layer, operation proceeds into the scan layer.

Scan layer

In general, the instrument requires a scan event to allow operation to proceed to the channel layer. With Immediate scan spacing selected, operation immediately proceeds to the next layer. With one of the trigger scan spacing events selected (Timer, External, GPIB, Manual, Trigger Link), the instrument will wait until the appropriate event occurs. With Timer scan spacing selected, the first pass through the scan layer will occur immediately. If programmed for additional scans, the instrument will wait until the Timer times out. The Timer can be set for an interval from 1msec to 99999.999 seconds.

The scan count (number of scans) can be set to a finite value (1 to 9999) or for an infinite number of scans.

After the instrument leaves the scan layer, operation proceeds into the channel layer.

Channel layer

In general, channel events control the channel scan rate. With Immediate channel spacing selected, a channel will be scanned immediately. With one of the other channel spacing events selected (Timer, External, GPIB, Manual or Trigger Link), the instrument will wait until the appropriate event occurs before scanning a channel. With Timer channel spacing selected, the first channel will be scanned immediately. Each additional channel will wait for the Timer to time out before it will be scanned.

Typically, the channel count (number of channels to scan) is set to the number of channels that are contained in the Scan List (scan-list-length). However, the channel count can be set to a finite value (1 to 9999) or to infinity.

3.5 Initial configuration

WARNING

Before turning the Model 7001 on, make sure it is connected to a grounded power receptacle using the supplied power cord or the equivalent. Failure to properly ground the unit creates a shock hazard that could result in injury or death.

Before performing any basic operations (close/open channels or scan channels) there are a few initial configurations that must first be considered. If you are using Model 701X series cards (i.e. Model 7011, 7012 and 7013), and they are already installed in the mainframe (as explained in Section 2), skip the following configuration information and proceed to paragraphs 3.5 (front panel operation) and 3.6 (IEEE-488 bus operation).

3.5.1 Switching card simulators

Instrument operation can be performed without any switching cards installed in the Model 7001 by using the switching card simulators. By selecting the appropriate switching card simulator, the Model 7001 will operate as if a 40-channel switching card or a 4 × 10 matrix card were installed. This is useful if you want to develop a test program without having a card installed.

When a slot is assigned the model number 9990, the mainframe will operate as if a 40-channel switching card is installed. When a slot is assigned model number 9991, the mainframe will operate as if a 4 × 10 matrix

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card is installed. These simulator model numbers are assigned by setting card TYPE in the CARD CONFIG MENU (see paragraph 3.5.3). If you are going to use the simulators to perform the operating examples in paragraph 3.6, configure Slot 1 for non-matrix switching (model 9990), and Slot 2 for matrix switching (model 9991).

NOTE

A simulator cannot be assigned to a slot that already has a Model 701X series card installed in it. To use a simulator, turn off the Model 7001 and remove the card from the slot.

3.5.2 Installing switching cards

The procedure to install switching cards in the mainframe is explained in Section 2 of this manual. If using switching card simulators as explained in the previous paragraph, leave the slots empty.

3.5.3 Card type

In order for the Model 7001 to operate properly, it must know what type of card is installed in each of its two slots. If a Model 701X series card (such as the Model 7011, 7012 or 7013) is installed in a slot, the mainframe automatically identifies the card type on power-up and configures its operation appropriately. With Model 701X series cards installed in the mainframe, you can disregard the procedure in this paragraph and proceed on to basic front panel operation (paragraph 3.5).

For other card types (non-701X series cards) and simulators, the user must assign the proper model number to the slot. Once a model number is assigned by the user, it will be remembered on subsequent power-ups as long as a Model 701X series card is not installed. Note that a slot can also be designated as empty. With this assignment, the front panel status display for that slot will be disabled.

A slot assignment change could make a channel that is currently included in the Scan List and/or a Channel Pattern unavailable. The unavailable channel causes the Scan List and/or the affected Channel Pattern to clear (see paragraphs 4.5.2 and 4.5.5 for details).

Perform the following procedure to assign a model number (or designate it as empty) to one or both of the mainframe slots:

1. Turn on the Model 7001. During the power-up sequence, the instrument will briefly display which Model 701X series cards are currently installed, or the last slot assignments.

   Example — If a Model 7013 card is installed in slot 1, and slot 2 was last designated to be empty, the following message will be displayed briefly during the power-up sequence:

   ```
   #1 = 7013     #2 = NONE
   ```

   If slot 2 is empty and you do not wish to assign it a simulator, stop here and proceed to basic front panel operation (paragraph 3.5). If slot 2 has a non-701X series card (i.e. Model 7156) installed in it, continue with this procedure to assign the appropriate model number to the slot.

2. Press CARD CONFIGURATION to enable the following menu:

   ```
   CARD CONFIG MENU
   TYPE   #-OF-POLES   CARD-PAIR ▶
   ◀ DELAY   READ-I/O-CARD
   ```

   NOTE

   A displayed arrow (◀ or ▶) indicates that more menu selections are available. Use the cursor keys (◁ and ▷) to display them.

3. Using the ◁ and ▷ cursor keys, place the cursor (flashing menu item) on TYPE and press ENTER. The following menu will be displayed:

   ```
   SET CARD TYPE
   SLOT-1   SLOT-2
   ```

4. Place the cursor on the slot that needs to be assigned and press ENTER. For example, if you selected Slot 1, the following typical message will be displayed:

   ```
   SLOT-1 CARD: NONE
   ```

   The above message indicates that there is not a Model 701X series card installed in slot 1, and slot 1 was last designated as an empty slot.

5. Perform one of the following steps:
   A. Empty Slot — If you want to assign the slot as empty, use the cursor keys (◁ and ▷) to display the "NONE" message. Example:

      ```
      SLOT-1 CARD: NONE
      ```

      The above message indicates that, when ENTERed (Step 6), slot 1 will be configured to operate as an empty slot.

   B. Simulator — If you want the slot to simulate a 40- channel switching card, use the cursor keys (◁ and ▷) to display model number 9990. If you want the slot to simulate a 4 × 10 matrix card, use the cursor keys to display model number 9991. Example:

      ```
      SLOT-1 CARD: 9990
      ```

      The above message indicates that, when ENTERed (Step 6), slot 1 will be configured to operate as a 40-channel switching card.

   C. Non-701X Series Card — To assign the slot to the non-701X series card, use the cursor keys (◁ and ▷) to display the model number of that card. For example, if a Model 7156 is installed in slot 1, use the cursor keys to display the following message:

      ```
      SLOT-1 CARD: 7156
      ```

      The above message indicates that, when ENTERed (Step 6), slot 1 will operate properly with a Model 7156 installed in it.

6. With the appropriate slot assignment message displayed, press ENTER to execute the assignment. The display will return to the SET CARD TYPE menu.
7. To assign the other slot, repeat steps 4 through 6.
8. To exit from the CARD CONFIG MENU, press EXIT twice.

NOTE

The EXIT key can be used anywhere in the CARD CONFIG MENU structure. Each press of the EXIT key will back up the display to the previous menu level without executing a pending operation.

3.6 Front panel operation

Basic front panel operation will be demonstrated through the use of examples. One example demonstrates close/open operation and the other example demonstrates scanning. These examples are only intended to teach basic operation. Complete details for using the full capabilities of the Model 7001 from the front panel are contained in Section 4 of this manual.

NOTE

Operation examples assume that the Model 7001 is initially configured for proper operation as explained in paragraph 3.5.

3.6.1 Close/open operation example

One of the basic functions of the Model 7001 is to simply close and open one or more specified channels. The following example will demonstrate this operation.

The example can be performed if you have a non-matrix switching card installed and/or a matrix card installed. If using the card simulators, configure slot 1 for non-matrix switching (model 9990) and slot 2 for matrix switching (model 9991) as explained in paragraph 3.5.3.

Channels that are controlled in this example include:

Switching Card Channels: 1, 3, 4, 5 and 6.

Matrix Card Channels: Row 1 Column 1, Row 2 Column 2, Row 2 Column 3, Row 2 Column 4, Row 2 Column 5 and Row 2 Column 6

Perform the following steps to close/open channels of a non-matrix switching card and/or a matrix card.

Step 1. Place instrument in Channel List display state.

If not already in the channel status display state, press EXIT one or more times. Once in the channel status display state, the SCAN KEY will toggle between the Channel List (SELECT CHANNELS) and the Scan List (SCAN CHANNELS).

```
SELECT CHANNELS
```

If there is Channel List currently displayed, press CLEAR LIST to cancel it. Also, if there are any channels currently closed, press OPEN ALL to open them.

Step 2. Enter Channel List.

Switching Card — For a non-matrix switching card, enter the Channel List (Channels 1, 3, 4, 5 and 6) for slot 1 as follows:

> **NOTE**
>
> The following procedure assumes that slot 1 is configured for non-matrix switching. If using slot 2 for non-matrix switching, modify (A) of steps 1 and 2 by pressing "2" instead of "1".

1. Enter first channel (Channel 1) using the single channel entry method:

A.	Press "1"	Enters slot
B.	Press "1"	Enters channel
C.	Press "▷ " or "ENTER"	Enters channel separator (comma)

```
SELECT CHANNELS 1!1,
```

2. Enter the rest of the channels (Channels 3 through 6) using the channel range entry method:

A.	Press "1"	Enters slot
B.	Press "3"	Enters first channel
C.	Press "-"	Enters range designator and slot
D.	Press "6"	Enters last channel
E.	Press "▷ " or "ENTER"	Enters channel list terminator (comma)

```
SELECT CHANNELS 1!1, 1!3-1!6,
```

Note: Channels 3, 4, 5, and 6 could have been entered using the single channel entry method demonstrated in step 1.

Matrix card—For a matrix card, enter the Channel List (Row 1 Column 1,Row 2 Column 2, Row 2 Column 3, Row 2 Column 4, and Row 2 Column 5 for slot 2) as follows:

Note: The following procedure assumes that Slot 2 is configured for a matrix. If using slot 1 for a matrix, modify (A) of steps 1 and 2 by pressing "1" instead of "2" to enter the slot.

1. Enter first channel (Row 1 Column 1) using the single channel entry method:

A.	Press "2"	Enters slot
B.	Press "1"	Enters row
C.	Press "1"	Enters column
D.	Press "▷ " or "ENTER"	Enters channel separator (comma)

```
SELECT CHANNELS 2!1!1,
```

2. Enter the rest of the channels (Row 2 Column 2 through Row 2 Column 5) using the channel range entry method:

A.	Press "2"	Enters slot
B.	Press "2"	Enters row of first channel
C.	Press "2"	Enters column of first channel
D.	Press "-"	Enters range designator
E.	Press "2"	Enters row of last channel
F.	Press "5"	Enters column of last channel
G.	Press "▷ " or "ENTER"	Enters channel list terminator (comma)

```
SELECT CHANNELS 2!1!1, 2!2!2-2!2!5,
```

Note: The single channel entry method demonstrated in step 1 could have been used to enter the channels for row 2.

Step 3. Close (or open) listed channels.

1. To close the channels specified in the channel list, simply press CLOSE. The closed channels will be indicated on the channel status display.
2. To open the closed channels that are specified in the channel list, press OPEN. Note that only channels specified in the list are opened. Unspecified channels (as well as channels in the channel list) are opened by pressing OPEN ALL.

Closing additional channels

After you have closed the channels in channel list, you may want to close one or more additional channels. Closing an additional channel is simply a matter of entering the channel in the channel list and pressing "CLOSE". For example, assume your channel list looks like this:

```
SELECT CHANNELS 1!1, 1!3-1!6,
```

To close channel 1!8, position the cursor at the end of the channel list and press "1", "8" and then CLOSE. The channel list will now look like this:

```
SELECT CHANNELS 1!1, 1!3-1!6, 1!8,
```

You could also have closed the additional channel by first clearing the channel list (pressing CLEAR LIST), and then entering and closing the channel. However, keep in mind that once you clear a channel list, it cannot be recalled. You will have to re-enter the entire list.

Opening closed channels

As previously explained, pressing OPEN will open all the channels specified in the channel list. If you want to open one or more, but not all channels, you will have to clear the channel list by pressing CLEAR LIST, and then enter a new channel list that specifies the closed channels you wish to open. Once the new channel list is entered, simply press OPEN to open those channels.

3.6.2 Scan operation example

The Model 7001 can scan through a list of specified channels. The order of the channels in the Scan List determines the channel order for the scan. The following example will demonstrate this operation.

The example can be performed if you have a non-matrix switching card installed and/or a matrix card installed. If using the card simulators, configure slot 1 for non-matrix switching (model 9990), and slot 2 for matrix switching (model 9991) as explained in paragraph 3.4.3.

Channels that are scanned in this example include:

Switching Card Channels: 1, 3, 4, 5, and 6.

Matrix Card Channels: Row 1 Column 1, Row 2 Column 2, Row 2 Column 3, Row 2 Column 4, Row 2 Column 5 and Row 2 Column 6.

Perform the following steps to scan channels of a non-matrix switching card and/or a matrix card. Three scans of the specified Scan List will be performed.

Step 1. RESET the Model 7001.

By performing RESET, the Model 7001 will set itself to default conditions that are typically used to control a scan.

1. Press the MENU key. The following menu will be displayed:

```
MAIN MENU
SAVESETUP  GPIB  DIGITAL-I/O ▶
◀ TEST  LANGUAGE  GENERAL
```

2. Use the cursor keys (◁ and ▷) to place the cursor (flashing menu item) on SAVESETUP and press the ENTER key. The following menu will be displayed:

```
SETUP MENU
SAVE  RESTORE  PWRON  RESET
```

3. Place the cursor on RESET and press ENTER. The following message will be displayed;

```
RESETTING INSTRUMENT
```

4. Press ENTER. The following message will be displayed:

```
RESET COMPLETE
```

5. Again press ENTER to return to the SETUP MENU.
6. Press EXIT twice to exit from the menu structure.

Step 2. Place instrument in Scan List display state.

With the instrument in the Channel List display state, press SCAN LIST to select the Scan List entry display state. The following message prompt will be displayed:

```
SCAN CHANNELS
```

If there is a scan list currently displayed, press CLEAR LIST to cancel it. Also, if there are any channels currently closed, press OPEN ALL to open them.

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Step 3. Enter Scan List.

Switching Card — For a non-matrix switching card, enter the scan list (Channels 1, 3, 4, 5, and 6) for slot 1 as follows:

Note: The following procedure assumes that slot 1 is configured for non-matrix switching. If using slot 2 for non-matrix switching, modify (A) of steps 1 and 2 by pressing "2" instead of "1".

1. Enter first channel (Channel 1) using the single channel entry method:

A. Press "1"	Enters slot
B. Press "1"	Enters channel
C. Press " ▷ " or "ENTER"	Enters channel separator (comma)

```
SCAN CHANNELS 1!1,
```

2. Enter the rest of the channels (Channels 3 through 6) using the channel range entry method:

A. Press "1"	Enters slot
B. Press "3"	Enters first channel
C. Press "-"	Enters range designator and slot
D. Press "6"	Enters last channel
E. Press " ▷ " or "ENTER"	Enters channel list terminator (comma)

```
SCAN CHANNELS 1!1, 1!3-1!6,
```

Note: Channels 3, 4, 5 and 6 could have been entered using the single channel entry method demonstrated in step 1.

Matrix Card — For a matrix card, enter the scan list (Row 1 Column 1, Row 2 Column 2, Row 2 Column 3, Row 2 Column 4, and Row 2 Column 5 for slot 2) as follows:

Note: The following procedure assumes that slot 2 is configured for a matrix. If using slot 1 for a matrix, modify (A) of steps 1 and 2 by pressing "1" instead of "2".

1. Enter first channel (Row 1 Column 1) using the single channel entry method:

A. Press "2"	Enters slot
B. Press "1"	Enters row
C. Press "1"	Enters column
D. Press " ▷ " or "ENTER"	Enters channel separator (comma)

```
SCAN CHANNELS 2!1!1,
```

2. Enter the rest of the channels (Row 2 Column 2 through Row 2 Column 5)using the channel range entry method:

A. Press "2"	Enters slot
B. Press "2"	Enters row of first channel
C. Press "2"	Enters column of first channel
D. Press "-"	Enters range designator and slot
E. Press "2"	Enters row of last channel
F. Press "5"	Enters column of last channel
G. Press " ▷ " or "ENTER"	Enters channel list terminator (comma)

```
SCAN CHANNELS 2!1!1, 2!2!2-2!2!5,
```

Note: The single channel entry method demonstrated in step 1 could have been used to enter the channels for row 2.

Step 4. Configure channel layer of scan.

NOTE

When RESET was performed (Step 1), the channel layer was reset to MANUAL channel scanning. In MANUAL, the first press of STEP will take the instrument out of the idle state and each subsequent press will manually step through the scan. Go ahead and try it. When finished, press OPEN ALL to place the Model 7001 in the idle state.

For this example, the channel scan rate will be controlled by the timer. In general, every time the timer times out, the next channel in the scan will be selected.

Since the Model 7001 was RESET, only CHANNEL SPACING needs to be programmed.

Configure the channel layer as follows:

1. Press SCAN CONFIGURATION to display the following menu:

```
CONFIGURE SCAN
CHAN-CONTROL   SCAN-CONTROL ▶
◀ ARM-CONTROL   CHAN-RESTRICTIONS
```

2. Using the cursor keys (◁ and ▷), place the cursor on CHAN-CONTROL (Channel Layer) and press ENTER. The following menu will be displayed:

```
CHANNEL CONTROL
CHANNEL-SPACING   NUMBER-OF-CHANS ▶
◀ CONTROL
```

3. Place the cursor on CHAN-SPACING and press ENTER. The following menu will be displayed:

```
SELECT CHAN SPACING
TIMER   EXTERNAL   GPIB   MANUAL ▶
◀ TRIGLINK   IMMEDIATE   HOLD
```

4. Place the cursor on TIMER and press ENTER. The current timer interval (in seconds) will be displayed:

```
INTERVAL = 00000.001
```

The above message indicates that the timer is currently set for 1msec.

5. Set the timer for a half second interval by using the cursor keys and number keys. The timer interval should look like this:

```
INTERVAL = 00000.500
```

6. Press ENTER to select the timer as the event that controls the channel scan. The display returns to the following menu:

```
CHANNEL CONTROL
CHANNEL-SPACING   NUMBER-OF-CHANS ▶
◀ CONTROL
```

Note: When the Model 7001 was RESET, the number of channels to scan was set to the scan list length, which is what you want for this example.

7. Press EXIT to return the display to the CONFIGURE SCAN menu.

Step 5. Configure scan layer of scan.

When the Model 7001 was RESET (Step 1), the scan layer was reset to IMMEDIATE scan spacing, which is appropriate for this example. This means each programmed scan will occur immediately and not wait for an event to occur.

Also, the scan layer was RESET to perform an infinite number of scans. Since this example requires only three scans, change the NUMBER OF SCANS as follows:

1. The Model 7001 should be displaying the following menu:

```
CONFIGURE SCAN
CHAN-CONTROL   SCAN-CONTROL ▶
◀ ARM-CONTROL   CHAN-RESTRICTIONS
```

2. Place the cursor on SCAN-CONTROL and press ENTER. The following menu will be displayed:

```
SCAN CONTROL
SCAN-SPACING   NUMBER-OF-SCANS ▶
◀ CONTROL
```

3. Place the cursor on NUMBER-OF-SCANS and press ENTER. The following menu will be displayed:

```
NUMBER OF SCANS
INFINITE   ENTER-SCAN-COUNT
```

4. Place the cursor on ENTER-SCAN-COUNT and press ENTER. The following typical message indicating the scan count will be displayed:

```
SCAN COUNT = 0000
```

A scan count of zero indicates that the scan layer is currently configured for an infinite number of scans.

5. Key in a scan count of 3.

```
SCAN COUNT = 0003
```

6. To configure the instrument for three scans, press ENTER. The display will return to the SCAN CONTROL menu.
7. Press EXIT twice to exit from the menu structure.

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Note: RESET (Step 1) configured the arm layer for IMMEDIATE arming, and for an arm count of one. Both of these arm conditions are appropriate for this example. Thus, arm layer configuration is not necessary.

Step 6. Perform the scan.

To perform the scan, simply press the STEP key. On the display, the scan will arm (ARM indicator will turn on), and the mainframe will scan through the channels of the scan list three times. At the conclusion of the third scan, the Model 7001 will return to the idle state (ARM indicator will turn off). Note however that the last channel in the scan list remains closed.

NOTE

The last channel in the scan remains closed. If your test requires that the last channel open after the scan, proceed to the next step.

Step 7. Open the last channel

To have the last channel open at the conclusion of the third scan, you will need to assign a blank channel pattern (all channels open) from memory as the last channel entry in the Scan List.

To save a blank channel pattern in memory, perform the following steps:

1. Display the Channel List (SELECT CHANNELS) and press OPEN ALL to open all channels.
2. Press STORE. The following typical message will be displayed:

```
STORE CHANS AT #001
```

3. To store the blank channel pattern in memory location 1, press ENTER. Note that the blank channel pattern could have been stored at any one of the 100 memory locations (1 to 100) by keying in the desired value and then pressing ENTER.

With a blank channel pattern stored at memory location 1 (M1), add it to your Scan List as follows:

1. Display the scan list (press SCAN LIST if necessary).
2. Use the ▷ cursor key to position the cursor at the end of the scan list.
3. Enter the blank channel pattern by pressing "M", "1" and then ▷ or ENTER to terminate the Scan List.

```
SCAN CHANNELS 1!1, 1!3-1!6, 2!1!1, 2!2!2-2!2!5, M1,
```

Repeat the scans by again pressing STEP. At the conclusion of the third scan, the last channel (Channel 2!2!5, if using the scan list above), will open.

3.7 IEEE-488.2 and SCPI basics

The following paragraphs discuss fundamental information concerning operation over the IEEE-488 bus. Detailed information on operating the instrument from over the bus is contained in Section 5 of this manual.

SCPI overview

IEEE-488.2 defines a syntax for sending data to and from instruments. It also defines a set of Common Commands that are used to perform basic operations such as reading status registers, providing triggers and resetting the instrument to default conditions.

SCPI (Standard Commands for Programmable Instruments) defines a standard set of commands (and format) to control every other aspect of instrument operation. Together, IEEE-488.2 and SCPI create a command structure for all programmable instruments.

Compatibility

An instrument that uses the IEEE-488.2 standard and SCPI does not have any special hardware requirements. The IEEE-488 interface that you used with the old standard will work with the new standard. Simply connect the Model 7001 to a computer that is equipped with an IEEE-488 interface.

NOTE

The term GPIB (General Purpose Interface Bus) is used in this manual and in the menu structure of the instrument. GPIB is simply another term for the IEEE-488 bus.

3.7.1 Bus connections

Before using the instrument over the bus, you must connect the IEEE-488 connector on the rear panel of the instrument to the IEEE-488 connector of your controller. Use a Keithley Model 7007 or similar IEEE-488 cable for this connection.

3.7.2 Primary address

The primary address of the Model 7001 must agree with the primary address you intend to specify in the controller's programming language. The factory setting for the primary address is 7, so if you intend to use that address, you need not change it. However, the primary address can be set to any value between 0 and 30 by using the GPIB setup menu (ADDRESS selection) available with the MENU key.

3.7.3 Abbreviated common command summary

Table 3-1 provides an abbreviated list of Common Commands which are defined by the IEEE-488.2 standard. These are the Common Commands that are most used for bus operation. Note that each Common Command is preceded by a star (*).

3.7.4 Abbreviated SCPI command summary

Most instrument operations are controlled using SCPI commands. Table 3-2 provides an abbreviated list of the SCPI commands necessary to perform some basic operations.

Not shown in the table are companion query commands for the :ARM and :TRIGger Subsystem commands (:COUNt?, :DELay?, :SOURce?, and :TIMer?). For example, the :TRIGger:SOURce? query command is used to request the currently selected control source. After the query command is sent and the Model 7001 is addressed to talk, a message identifying the selected control source will be sent to the computer.

Table 3-1
Abbreviated common command summary

Mnemonic	Name	Description
*CLS	Clear status	Clears Error Queue and event registers.
*RST	Reset	Returns the 7001 to *RST default conditions (see Table 5-6).
*TRG	Trigger	Issues a bus trigger (same as group execute trigger command; GET).
*SAV <n>	Save	Saves the current setup configuration in memory (n = 0 to 9).
*RCL <n>	Recall	Returns the instrument to the setup configuration stored in memory (n = 0 to 9).

Table 3-2
Abbreviated SCPI command summary

:SYSTem	Subsystem command path.
:PRESet	Set scan to a default configuration (see Table 5-6)
[:ROUTe]	Subsystem command path.
:CLOSe <list>	Path and command to close specified channels:
:STATe?	Request channels that are closed.
:OPEN <list> | ALL	Open specified (or all) channels.
:SCAN <list>	Path and command to specify channel list:
:INITiate	Initiate one trigger (scan) cycle.
:ABORt	Reset trigger system and goes to idle state.
:ARM	Subsystem command path to configure scan:
:LAYer2	Path to program scan layer:
:COUNt <n> | INF	Program number of scans (1 to 9999, or INFinite).
:DELay <num>	Program delay (0 to 99999.999 seconds
:SOURce HOLD | IMMediate | TIMer | MANual | BUS | TLINk | EXTernal	Select event to control scan spacing.
:TIMer <num>	Set timer interval (0.001 to 99999.999 sec).
:TRIGger	Subsystem command path to program channel layer:
:COUNt <n> | INF	Program number of channels (1 to 9999, or INFinite).
:AUTo ON/OFF	Enable/disable automatic scan list count.
:DELay <num>	Program delay (0 to 99999.999 sec)
:SOURce HOLD | IMMediate | MANual | BUS | TLINk | EXTernal | TIMer	Select event to control channel spacing.
:TIMer <num>	Set timer interval (0.001 to 99999.999 sec).

Note: Command shortform is indicated by the uppercase characters. For example, instead of sending ":arm:layer2:source immediate", you can send ":arm:lay2:sour imm".

3.7.5 Syntax rules

The following information explains some of the programming syntax for the Model 7001. For more complete information see Programming Syntax which is located just after the tab labled "SCPI Command Subsystems".

General form

The general form for SCPI commands is demonstrated in Table 3-2. Notice that they are hierarchical in nature and begin with a root command. For example, to open all channels, you would send the following command:

```
:OPEN    ALL
```

The root command for the above example is :ROUTe. This is an optional command word (as indicated by the brackets in the table) and need not be used.

Note that there must be a space between the command word and the parameter. In the above example, there is a space between the :OPEN command word and the ALL parameter.

SCPI command words and Common Commands are not case sensitive. They can be sent in uppercase or lowercase. The commands in Table 3-2 show a combination of upper and lowercase characters. The uppercase characters identify the short-form version of the command. For example, all the following versions of the same program message are valid:

```
:ARM:LAYER2:SOURCE MANUAL
:ARM:LAY2:SOUR MAN
:arm:layer2:source manual
:arm:lay2:sour man
:Arm:Lay2:Sour Man
:ArM:LaY2:SouR MaN
```

Parameters

As previously mentioned, a parameter is separated from the command word by a space. The parameter can consist of one or more data types such as channel list, real, integer, string, name or boolean. Examples:

1. :open (@ 1!1, 1!2)
2. :open all
3. :scan (@ 1!1:1!10)
4. :trigger:count:auto on
5. :trigger:delay 0.5

1. (@ 1!1, 1!2) — This list parameter is used to specify a Channel List. Parentheses ( ) are used to enclose the list of channels. The @ symbol must precede the first channel in the list. The exclamation point (!) is a SCPI delimiter used to separate the slot number from the card relay number. Each channel in the list must be separated by a comma (,).
2. All — This name parameter can instead be used as the parameter for the :OPEN command if you wish to open all channels.
3. (@ 1!1:1!10) — This list parameter is used to specify a Scan List. This is the same type of parameter used in Example 1. In this example, Channels 1 through 10 are specified. Notice that the colon (:) is used as a separator for the range limits.
4. On — This boolean parameter is used to enable an automatic scan list count. A "1" could have instead been used. "Off" or "0" will disable the function.
5. 0.5 — This real number parameter sets the delay period in seconds.

Multiple commands

Multiple commands can be sent in the same message as long as they are separated by semicolons (;). For example:

Instead of sending...

```
:system:error?
:system:preset
```

You can send ...

```
:system:error?;preset
```

When the above message is sent, the first command word is recognized as the root command. When the path pointer sees the colon (:) after the semicolon (;), it resets to the root and starts over.

Proper use of the path pointer allows commands in the same command level to be serviced without having to re-type the entire command path. For example, the command :ARM:LAYer2:SOURce MANual moves the path pointer down to the last command level in the path. As a result, the :COUNt, :DELay, and :TIMer commands and their companion query commands can be included in the same program message without repeating the entire path. Examples:

Instead of sending...

```
:arm:lay2:sour man;:arm:lay2:sour?
```

You can send ...

```
:arm:lay2:sour man;sour?
```

Instead of sending...

```
:trig:coun 1;:trig:del 1;:trig:tim 1
```

You can send ...

```
:trig:coun 1;del 1;tim 1
```

Notice that the colon (:) for the additional commands is not included. Remember, when a colon (not preceeded by a semicolon) is seen, the path pointer moves down to the next command level. For example:

```
:trig:del 1;coun:auto on
```

When this message is sent, the path pointer moves down one command level for the DELAY and COUNT commands. The colon after the COUNT command then moves the pointer down to the next command level and enables AUTO.

A couple of important points:

1. The path pointer can only move down. It cannot be moved up a level.
2. Each new message (line) must begin with the root command.
3. Any time one or more query commands are included in a program message, the Model 7001 must be addressed to talk to send the response message to the computer.

3.7.6 Programming examples

The following programming examples are written in Hewlett-Packard BASIC 4.0 programming language. The programs assume that the Model 7001 is set to primary address 7.

Programming example #1 — closing and opening channels

The following program will close channels 1, 3, 4, 5, and 6 of slot 1, and then open them after a short delay:

```
10  OUTPUT 707; “*RST;:open all”
20  OUTPUT 707; “:clos (@ 1!1, 1!3:1!6)”
30  OUTPUT 707; “:clos:stat?”
40  ENTER 707; A$
50  PRINT A$
60  WAIT 3
70  OUTPUT 707; “:open (@ 1!1, 1!3:1!6)”
80  END
```

Line 10	Opens any channels that are closed.
Line 20	Close channels 1, 3, 4, 5, and 6 of slot 1.
Line 30	Request the closed channels.
Line 40	Address 7001 to talk.
Line 50	Display closed channels.
Line 60	Three second delay.
Line 70	Open the channels specified in the channel list.

Programming example #2 — manual scanning

The following program will configure the Model 7001 to perform an infinite number of manual scans of 10 channels for slot 1:

```
10  OUTPUT 707; “:syst:pres”
20  OUTPUT 707; “:scan (@1!1:1!10)”
30  OUTPUT 707; “:init”
40  END
```

Line 10	Return 7001 to :SYSTem:PRESet default configuration (scan count = infinite, channel count = 10 channels, channel control source = manual).
Line 20	Define scan list.
Line 30	Take 7001 out of idle state.

When the above program is run, the scan will arm (ARM indicator on) and then wait for front panel STEP key presses to control the channel scan. After taking the Model 7001 out of remote (press LOCAL key), each press of the STEP key will scan the next channel in the scan list.

Programming example #3 — bus trigger controlled scan

The program in Example #2 is modified so that the channel scan will be controlled by bus triggers (*TRG or GET):

```
10  OUTPUT 707; “:syst:pres”
20  OUTPUT 707; “:scan (@1!1:1!10)”
25  OUTPUT 707; “:trig:sour bus”
30  OUTPUT 707; “:init”
40 END
```

Line 10	Return 7001 to :SYSTem:PRESet default configuration (scan count = infinite, channel count = 10 channels, channel control source = manual).
Line 20	Define scan list.
Line 25	Program channel control source for bus triggers.
Line 30	Take 7001 out of idle state.

When the above program is run, the scan will arm and then wait for bus triggers to control the channel scan. Any of the following two programming statements can be used to provide a bus trigger:

```
OUTPUT 707; “*TRG”
TRIGGER 707
```

Every time one of the above statements is executed, a bus trigger will occur causing the next channel in the scan list to be scanned.

Programming example #4 — timer controlled channel scan

The program in Example #2 is modified so that the channel scan will be controlled by a timer:

```
10  OUTPUT 707; ":syst:pres"
20  OUTPUT 707; ":scan (@1!1:1!10)"
25  OUTPUT 707; ":trig:sour tim"
26  OUTPUT 707; ":trig:tim 0.5"
30  OUTPUT 707; ":init"
40  END
```

Line 10	Return 7001 to :SYSTem:PRESet default configuration (scan count = infinite, channel count = 10 channels, channel control source = manual).
Line 20	Define scan list.
Line 25	Program channel control source for timer.
Line 26	Set timer for 0.5 second interval.
Line 30	Take 7001 out of idle state.

When the above program is run, the scan will arm and scan channels continuously at a 0.5 second rate.

Programming example #5 — timer controlled scan

The program in Example #4 is modified to perform two scans, the first scan will start immediately and the second scan will start 10 seconds after the start of the first scan:

```
10  OUTPUT 707; ":syst:pres"
20  OUTPUT 707; ":scan (@1!1:1!10)"
22  OUTPUT 707; ":arm:lay2:coun 2"
23  OUTPUT 707; ":arm:lay2:sour tim"
24  OUTPUT 707; ":arm:lay2:tim 10"
25  OUTPUT 707; ":trig:sour tim"
26  OUTPUT 707; ":trig:tim 0.5"
30  OUTPUT 707; ":init"
40  END
```

Line 10	Return 7001 to :SYSTem:PRESet default configuration (scan count = infinite, channel count = 10 channels, channel control source = manual).
Line 20	Define scan list.
Line 22	Program scan count to 2.
Line 23	Program scan control source for timer.
Line 24	Set timer for 10 second interval.
Line 25	Program channel control source for timer.
Line 26	Set timer for 0.5 second interval.
Line 30	Take 7001 out of idle state.

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Front Panel Operation

4.1 Introduction

This section covers all aspects of front panel operation. Paragraphs in this section are organized as follows:

4.2 Power-up procedure: Covers information on connecting the instrument to line power, and the power-up sequence.

4.3 Display: Covers the display formats and lists messages that may appear while using the instrument.

4.4 Analog backplane: Explains how two Model 701X series switching cards may be internally connected together through the analog backplane of the Model 7001.

4.5 Mainframe programming: Explains how to create a channel list and a scan list. The basic close/open operation and scan operation is covered here.

4.6 MENU: Covers miscellaneous operations and selections controlled from the MAIN MENU.

4.7 CARD CONFIG: Covers the various configuration operations for the two slots (Card 1 and Card 2) from the CARD CONFIG MENU.

4.8 SCAN CONFIG: Covers the CONFIGURE SCAN menu, which is used to configure the various layers of scan operation.

4.9 Digital I/O port: Describes the input/output port, which is made up of four output lines and one input line.

4.10 External triggering: Covers external triggering using the rear panel BNC connectors.

4.11 Trigger link: Covers external triggering using the trigger link.

4.2 Power-up procedure

The Model 7001 can be operated from line voltages from 90-260VAC at line frequencies from 47-440Hz.

4.2.1 Line power connections

Using the supplied power cord, connect the instrument to an appropriate AC power source. The female end of the cord connects to the AC receptacle on the rear panel of the instrument. The other end of the cord connects to a grounded AC outlet.

WARNING

The Model 7001 must be connected to a grounded outlet to maintain continued protection against possible shock hazards. Failure to use a grounded outlet may result in personal injury or death due to electric shock.

4.2.2 Power switch

To turn on the power, simply push in the front panel POWER switch. Power is on when the switch is at the inner (1) position. To turn off power, press POWER a second time to release the switch.

4.2.3 Power-up sequence

On power-up, the Model 7001 will go through the following sequence:

1. The instrument will perform self-tests on its EPROM and RAM memory elements. If a failure is detected, the instrument will lock up and display the following message:

   ```
   No Comm Link
   ```

   Note: If a problem develops while the instrument is under warranty, return it to Keithley Instruments, Inc. for repair.

2. If the instrument passes the self-tests, the firmware revision levels and currently selected IEEE-488 address will be displayed. An example of this display is shown as follows:

   ```
               Model 7001
   Rev. AXX AY     IEEE Addr = 07
   ```

   where:

   Rev. AXX is the firmware level for the main CPU.

   Rev. AYY is the firmware level for the display CPU.

   7 is the current IEEE-488 Address. Note that the instrument is shipped from the factory with the address set to 7.

3. The Model 7001 will then perform card identification (Card ID). Card ID is required so that the mainframe can configure itself to operate properly for installed cards. Card ID is described as follows:

   Model 701X series cards — If a Model 701X series card (i.e. 7011, 7012 or 7013) is installed in the mainframe, it will be automatically identified. The operator need not do anything. For example, if a Model 7011 multiplexer card is installed in slot 1 and a Model 7012 matrix card is installed in slot 2, the following message will be displayed briefly:

   ```
   #1 = 7011    #2 = 7012
   ```

   Non-701X series cards — The Model 7001 cannot automatically identify non-701X series cards. The model numbers of these cards are entered by the user using the Card Configuration menu (see paragraph 4.7). On power-up, the mainframe checks its memory and displays the model number last entered by the user. For example:

   ```
   #1 = 7052    #2 = NONE
   ```

   "7052" indicates that a Model 7052 card was last assigned to slot 1. There may or may not be a Model 7052 card currently installed in slot 1. The message "NONE" indicates that the user last designated slot 2 to be empty, or the last card installed in the now empty slot was a Model 701X series card. Slot 2 may be empty or it may contain an unassigned non-701X series card.

   "9990" or "9991" indicates that the slot was assigned by the user to simulate a switching card. With "9990" assigned, the mainframe will operate as if a 40 channel multiplexer card is installed. With "9991" assigned, the mainframe will operate as if a 4 × 10 matrix is installed. This simulation mode allows you to develop and test a switching system without having the card installed.

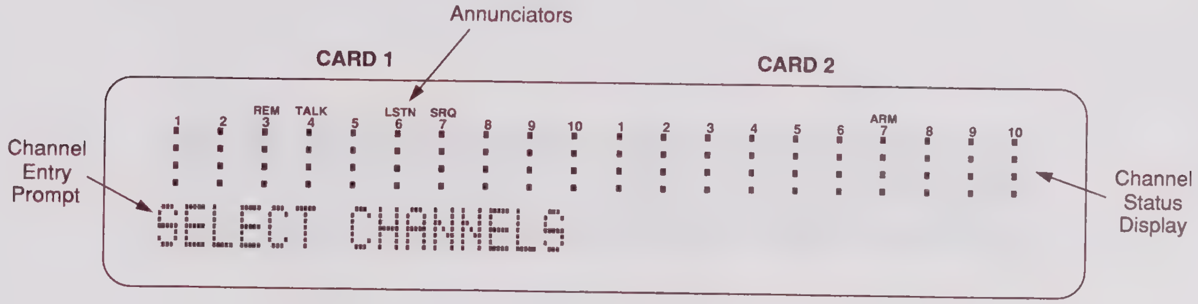
   NOTE

   For non-701X series cards, make sure that the power-up Card ID model number messages correspond to what is actually installed in the mainframe. Use the Card Configuration menu (see paragraph 4.7) to assign the correct model numbers to the slots.

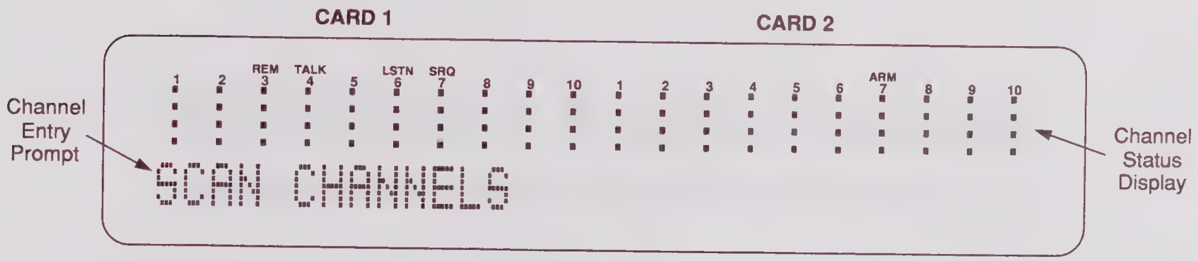
4. After card identification, the instrument will go to the channel status display state (see paragraph 4.3 Display).

4.3 Display

The display of the Model 7001 (see Figure 4-1) is primarily used to display channel status along with the entered channel list or scan list. When not displaying channel status, the display is used for informational type messages, such as menu headings and selections. At the top of the display are annunciators to indicate various states of operation.


Annunciators
CARD 1
CARD 2
REM
TALK
LSTN
SRQ
ARM
1 2 3 4 5 6 7 8 9 10
1 2 3 4 5 6 7 8 9 10
Channel Entry Prompt
SELECT CHANNELS
Channel Status Display

A) Channel List Display (Power Up Default)


CARD 1
CARD 2
REM
TALK
LSTN
SRQ
ARM
1 2 3 4 5 6 7 8 9 10
1 2 3 4 5 6 7 8 9 10
Channel Entry Prompt
SCAN CHANNELS
Channel Status Display

B) Scan List Display

Figure 4-1
Display format

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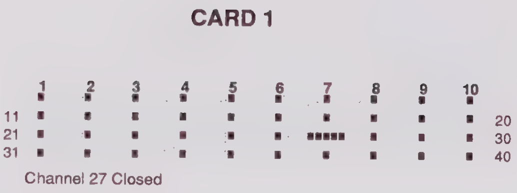
4.3.1 Channel status display

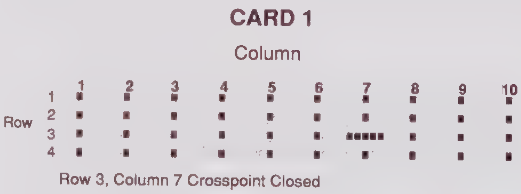
The channel status display provides real-time status (open or closed) of each available channel for the two slots; Card 1 and Card 2. Only available channels are displayed. A single "dot" indicates that the available channel is open. A "dash" (5 dots) indicates that the channel is closed (see Figure 4-2).

The channel entry prompt depends on which display mode is currently selected. After power-up, the instrument is in the channel list entry state (see Figure 4-1A) for basic close/open operation. When SCAN LIST is pressed, the instrument goes to the scan list entry state as shown in Figure 4-1B. In general, pressing the EXIT key will select the channel status display, and pressing the SCAN LIST key will toggle between the channel list and the scan list.

Channel designations for the channel status display depend on the type of card installed. For example, if a non-matrix type card (i.e. Model 7011 multiplexer or Model 7013 relay switch card) is installed, the channels would be numbered 1 through 40. Figure 4-3A shows Channel 27 of a non-matrix type card closed. If, however, a matrix card (i.e. Model 7012) is installed, channels are designated as row/column crosspoint coordinates. Figure 4-3B shows matrix crosspoint at Row 3, Column 7 closed.


CARD 1
1
2
3
4
5
6
7
8
9
10
11
21
31
20
30
40
Channel 27 Closed

A) Non-Matrix Type Cards


CARD 1
Column
Row
1
2
3
4
1
2
3
4
5
6
7
8
9
10
Row 3, Column 7 Crosspoint Closed

B) Matrix Cards

Figure 4-3
Interpreting channel status display

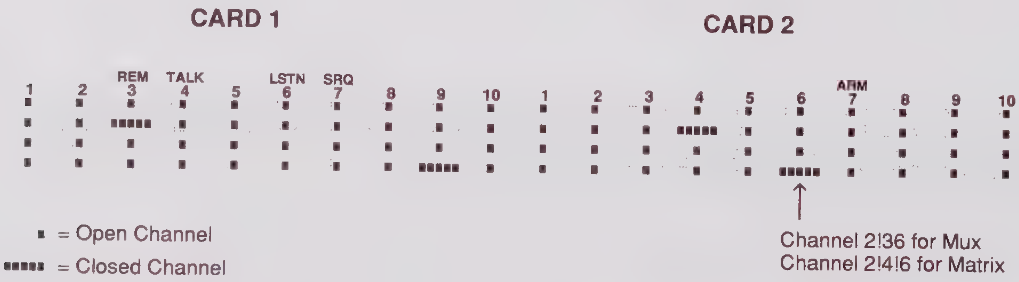

CARD 1
REM
TALK
LSTN
SRQ
1
2
3
4
5
6
7
8
9
10
CARD 2
ARM
1
2
3
4
5
6
7
8
9
10
▪ = Open Channel
▪▪▪▪▪ = Closed Channel
Channel 2!36 for Mux
Channel 2!4!6 for Matrix

Figure 4-2
Channel status display

4.3.2 Information and error messages

When not displaying channel status, the front panel display is used for other information messages, such as menu items, store and recall information, and error and status messages. Error and status messages for the Model 7001 are summarized in Table 4-1.

Also included is a front panel INFO key that displays helpful operating information about the feature you are trying to use. Pressing EXIT or INFO a second time will cancel the message.

4.3.3 Annunciators

The five annunciators along the top of the display indicate the following conditions:

SRQ — Turns on when the unit requests service over the IEEE-488 bus. Programming the Service Request Enable Register allows you to control which conditions will generate an SRQ (see Section 5).

REM —Turns on to indicate that the Model 7001 is in remote when used over the IEEE-488 bus. The Model 7001 can be placed in remote by addressing it to listen with the bus REN line true.

TALK — Turns on to indicate that the Model 7001 is the active talker on the IEEE-488 bus. The unit can be placed in the talker active state by sending it the correct bus talk command, which is derived from the primary address.

LSTN — Turns on when the unit is an active IEEE-488 bus listener. The Model 7001 can be placed in the active listener state by addressing it to listen.

ARM — Turns on when the Model 7001 is taken out of the idle state. A scan can only be performed with the Model 7001 out of the idle state.

Table 4-1
Error and status messages

Code number	Description
+550	"Forbidden channel error" (EE)
+522	"Slot 2 identification error" (EE)
+521	"Slot 1 identification error" (EE)
+510	"Saved state error" (EE)
+174	"Re-entering idle layer" (SE)
+173	"Waiting in arm layer 2" (SE)
+172	"Waiting in arm layer 1" (SE)
+171	"Waiting in trigger Layer" (SE)
+161	"Program running" (SE)
+126	"Device calculating" (SE)
+125	"Device measuring" (SE)
+124	"Device sweeping" (SE)
+123	"Device ranging" (SE)
+122	"Device settling" (SE)
+121	"Device calibrating" (SE)
+101	"Operation Complete" (SE)
0	"No error" (SE)
-100	"Command Error" (EE)
-101	"Invalid Character" (EE)
-102	"Syntax Error" (EE
-103	"Invalid Separator" (EE)
-104	"Data Type Error" (EE)
-105	"GET not allowed" (EE)
-108	"Parameter not allowed" (EE)
-109	"Missing Parameter" (EE)
-110	"Command Header Error" (EE)
-111	"Command Header Separator Error" (EE)
-112	"Program mnemonic too long" (EE)
-113	"Undefined header" (EE)
-114	"Header suffix out of range" (EE)
-120	"Numeric data error" (EE)
-121	"Invalid character in number" (EE)
-123	"Exponent too large" (EE)
-124	"Too many digits in number" (EE)
-128	"Numeric data not allowed" (EE)
-140	"Character data error" (EE)
-141	"Invalid character data" (EE)
-144	"Character data too long" (EE)
-148	"Character data not allowed" (EE)
-150	"String data error" (EE)
-151	"Invalid string data" (EE)
-154	"String too long"
-158	"String data not allowed" (EE)
-160	"Block data error" (EE)
-161	"Invalid block data" (EE)

Table 4-1 (cont.)
Error and status messages

Code number	Description
-168	"Block data not allowed" (EE)
-170	"Expression error" (EE)
-171	"Invalid expression" (EE)
-178	"Expression data not allowed" (EE)
-200	"Execution error" (EE)
-201	"Invalid while in local" (EE)
-202	"Settings lost due to rtl" (EE)
-210	"Trigger error" (EE)
-211	"Trigger ignored" (EE)
-212	"Arm ignored" (EE)
-213	"Init ignored" (EE)
-214	"Trigger deadlock" (EE)
-215	"Arm deadlock" (EE)
-220	"Parameter Error" (EE)
-221	"Settings conflict" (EE)
-222	"Parameter data out of range" (EE)
-223	"Too much data" (EE)
-224	"Illegal parameter value" (EE)
-241	"Hardware missing" (EE)
-260	"Expression Error" (EE)
-281	"Cannot create program" (EE)
-282	"Illegal program name" (EE)
-284	"Program currently running" (EE)
-285	"Program syntax error" (EE)
-330	"Self Test failed" (EE)
-350	"Queue overflow" (EE)
-410	"Query interrupted" (EE)
-420	"Query unterminated" (EE)
-430	"Query deadlocked" (EE)
-440	"Query unterminated after indefinite response" (EE)

EE = Error event
SE = Status event

4.4 Analog backplane

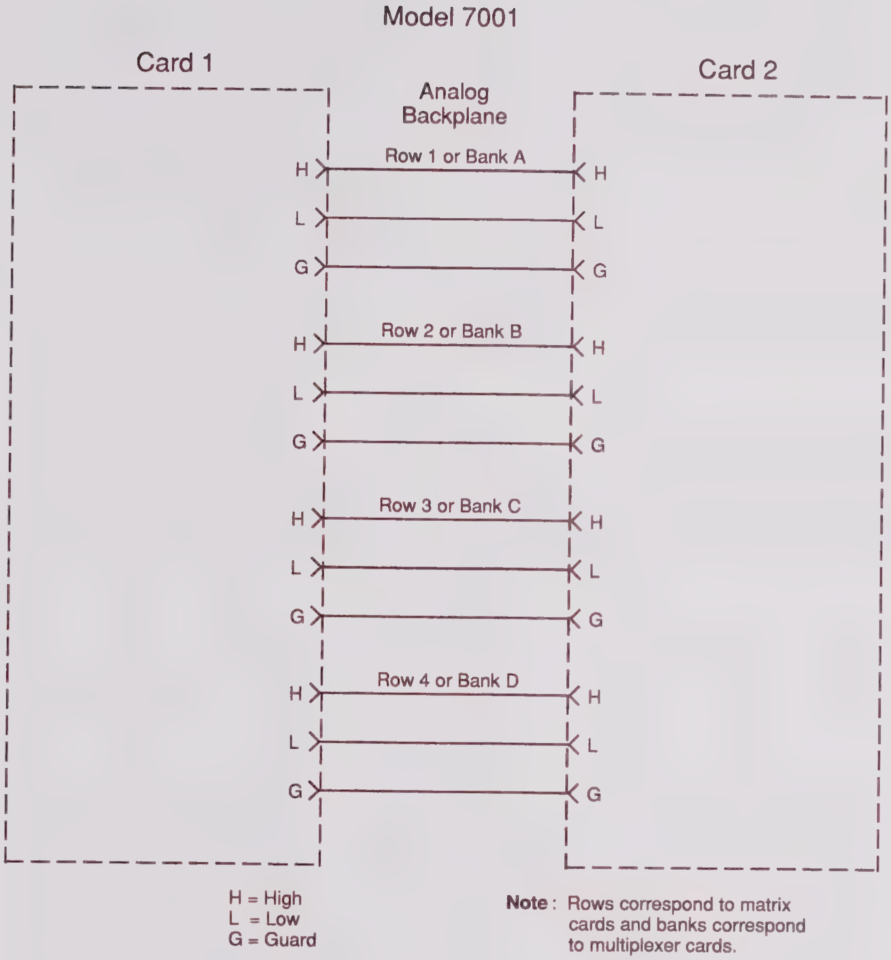
The Model 7001 has a three-pole analog backplane that allows the rows or banks of a Model 701X series card installed in one slot to be connected to the rows or banks of a second Model 701X series card installed in the other slot. The three-pole analog backplane of the mainframe is shown in Figure 4-4.

For example, if the backplane jumpers of two Model 7012 matrix cards are installed, the rows of the two cards are connected together by simply installing them in the mainframe. The result is a single 4 × 20 matrix. If the backplane jumpers on one or both of the matrix cards were removed, the two cards would be electrically isolated from each other resulting in two separate 4 × 10 matrices. Figure 4-5 shows how the Model 7012 matrix card is connected to the analog backplane. Note that the matrix card has only two poles (High and Low). The third pole (Guard) of the analog backplane is not used.

Keep in mind that not all Model 701X series cards can be connected to the analog backplane of the Model 7001. The Model 7013 Relay Switch Card is made up of 20 individual IN/OUT relay channels. Each channel is electrically isolated from each other. A Model 7013 installed in a slot of the mainframe will be electrically isolated from any other card installed in the other slot.

NOTE

The Model 7001 does not provide an analog backplane for non-701X series cards (such as the Model 7052). A non-701X series card installed in a slot of the mainframe will be electrically isolated from any other card installed in the other slot. The only way to connect one of these cards to a card in the other slot is to wire them together.


Model 7001
Card 1
Card 2
Analog Backplane
Row 1 or Bank A
Row 2 or Bank B
Row 3 or Bank C
Row 4 or Bank D
H
L
G
H = High
L = Low
G = Guard

Note : Rows correspond to matrix cards and banks correspond to multiplexer cards.

Figure 4-4
Model 7001 analog backplane

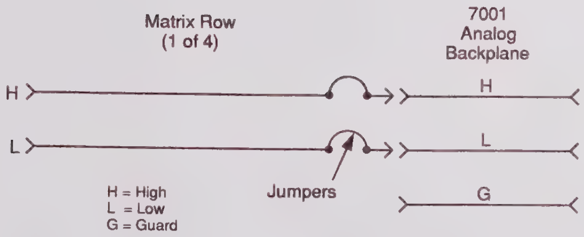

Matrix Row (1 of 4)
7001 Analog Backplane
H
L
G
Jumpers
H = High
L = Low
G = Guard

Figure 4-5
Matrix row connections to backplane

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4.5 Mainframe programming

The following paragraphs provides detailed information on programming the Model 7001 from the front panel to close channels and perform a scan.

4.5.1 Channel assignments

Channel assignments used to program the mainframe are based on the switching card type and the slot in which it is installed.

Non-matrix type cards: A non-matrix type card, such as the Model 7011 multiplexer card, simply consists of 40 channels (1-40) as shown in Figure 4-3A. When programming the Model 7001, you need to designate the slot in which the card is installed. Thus, combining the slot number with card channel number provides the CHANNEL assignment for the mainframe. The slot and card channel are separated by an exclamation point (!). For the following examples, "CHANNEL" refers to the programming channel assignment for the mainframe, while "Channel" refers to the channel number of the switching card.

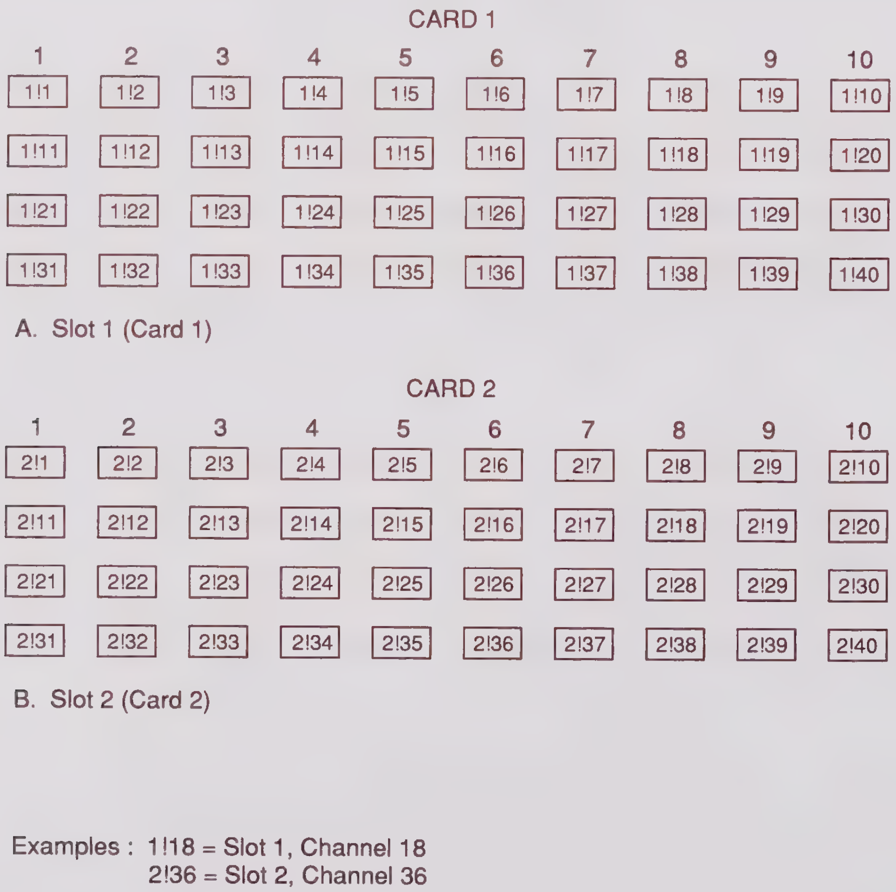
CHANNEL 1!1 = Slot 1, Channel 1

CHANNEL 1!20 = Slot 1, Channel 20

CHANNEL 2!2 = Slot 2, Channel 2

CHANNEL 2!36 = Slot 2, Channel 36

All mainframe channel assignments for non-matrix type switching cards are shown in Figure 4-6.



CARD 1

1	2	3	4	5	6	7	8	9	10
1!1	1!2	1!3	1!4	1!5	1!6	1!7	1!8	1!9	1!10
1!11	1!12	1!13	1!14	1!15	1!16	1!17	1!18	1!19	1!20
1!21	1!22	1!23	1!24	1!25	1!26	1!27	1!28	1!29	1!30
1!31	1!32	1!33	1!34	1!35	1!36	1!37	1!38	1!39	1!40

A. Slot 1 (Card 1)

CARD 2

1	2	3	4	5	6	7	8	9	10
2!1	2!2	2!3	2!4	2!5	2!6	2!7	2!8	2!9	2!10
2!11	2!12	2!13	2!14	2!15	2!16	2!17	2!18	2!19	2!20
2!21	2!22	2!23	2!24	2!25	2!26	2!27	2!28	2!29	2!30
2!31	2!32	2!33	2!34	2!35	2!36	2!37	2!38	2!39	2!40

B. Slot 2 (Card 2)

Examples : 1!18 = Slot 1, Channel 18
2!36 = Slot 2, Channel 36

Figure 4-6
Channel assignments (non-matrix type cards)

Matrix cards: Channels for a matrix card, such as the Model 7012, are organized as row/column crosspoints as shown in Figure 4-3B. When programming the Model 7001, you need to designate the slot in which the card is installed. Thus, combining the slot number with the crosspoint coordinates (row/column) provides the CHANNEL assignment for the mainframe. Slot, row, and column are separated by exclamation points (!). For the following examples, "CHANNEL" refers to the programming channel assignment for the mainframe.

CHANNEL 1!1!1 = Slot 1, Row 1, Column 1

CHANNEL 2!3!6 = Slot 2, Row 3, Column 6

All mainframe channel assignments for matrix cards are shown in Figure 4-7.

CARD 1

1	2	3	4	5	6	7	8	9	10
1!1!1	1!1!2	1!1!3	1!1!4	1!1!5	1!1!6	1!1!7	1!1!8	1!1!9	1!1!10
1!2!1	1!2!2	1!2!3	1!2!4	1!2!5	1!2!6	1!2!7	1!2!8	1!2!9	1!2!10
1!3!1	1!3!2	1!3!3	1!3!4	1!3!5	1!3!6	1!3!7	1!3!8	1!3!9	1!3!10
1!4!1	1!4!2	1!4!3	1!4!4	1!4!5	1!4!6	1!4!7	1!4!8	1!4!9	1!4!10

A. Slot 1 (Card 1)

CARD 2

1	2	3	4	5	6	7	8	9	10
2!1!1	2!1!2	2!1!3	2!1!4	2!1!5	2!1!6	2!1!7	2!1!8	2!1!9	2!1!10
2!2!1	2!2!2	2!2!3	2!2!4	2!2!5	2!2!6	2!2!7	2!2!8	2!2!9	2!2!10
2!3!1	2!3!2	2!3!3	2!3!4	2!3!5	2!3!6	2!3!7	2!3!8	2!3!9	2!3!10
2!4!1	2!4!2	2!4!3	2!4!4	2!4!5	2!4!6	2!4!7	2!4!8	2!4!9	2!4!10

B. Slot 2 (Card 2)

Examples : 1!2!4 = Slot 1, Row 2, Column 4
2!3!6 = Slot 2, Row 3, Column 6

Figure 4-7
Channel assignments (matrix cards)

4.5.2 Channel list and scan list

The Model 7001 can perform two basic operations; it can close and open a list of channels, and it can scan through a list of channels. The following paragraphs explain how to enter channels for these operations. The basic operations are explained in paragraphs 4.5.3 (Closing and Opening Channels) and 4.5.4 (Scanning Channels).

Each operation has its own list. For basic close/open operation, channels are entered into a channel list. For scan operation, channels are entered into a scan list. In general, press EXIT to select the channel status display (if not already displayed as shown in Figure 4-2) and press SCAN LIST to toggle between the channel list and scan list.

A programmed CHANNEL for the mainframe consists of the slot number and the card channel. Slot and card channel are separated by an exclamation point (!). For a matrix card, the card channel consists of a row and column that are also separated by an exclamation point (!). Individual CHANNELS in the defined list are separated by a comma (,). A range of CHANNELS is separated by a hyphen (-). A channel pattern stored in memory is designated by the letter "M" followed by the memory location number. Finally, the list is terminated by a comma (,).

For basic close/open operation, the order of channels in the channel list is not important since all listed channels will either close or open at the same time. For scan operation, the order of channels is important. Channels will be scanned in the order that they are presented in the scan list.

The Scan List is not lost (cleared) after the instrument is turned off. However, the Scan List is cleared if any of the following events occur:

1. A channel in the Scan List becomes unavailable. A channel can become unavailable by changing a slot assignment (Card TYPE) or by changing to a pole mode that reduces the number of available channels.
2. A channel in the Scan List becomes restricted. A channel becomes restricted by adding it to the restricted channel list.

The following examples demonstrate how the Scan List is lost:

1. Assume the Scan List includes channel 1!21 and the assignment for slot 1 is changed to a multiplexer card that has only 20 channels. Since channel 1!21 no longer exits, the entire Scan List is cleared.
2. Assume the Scan List includes channel 1!1 and the assignment for slot 1 is changed to a matrix card. Since channel 1!1 is an incorrect format for a matrix card, it no longer exists. The enire Scan List is cleared.
3. Assume the Scan List includes channel 1!21 and the slot (slot 1) is configured for 2-pole operation. Changing the pole-mode of slot 1 to 4-pole operation makes channel 1!21 unavailable and clears the entire Scan List.
4. Assume Channel Pattern M1 is included in the Scan List and M1 includes channel 1!1 as a closed channel. If channel 1!1 becomes unavailable, the entire Scan List is cleared. Also note that Channel Pattern M1 is also cleared (see paragraph 4.5.5).
5. Assume the Scan List includes channel 1!1. If channel 1!1 is then added to the restricted channel list, the entire Scan List is cleared.
6. Assume the Scan List includes channel 1!1 and Card Pair is enabled. Note that with card pair enabled, channel 2!1 is indirectly included in the Scan List. If cahnnel 2!1 is then added as a restricted channel, the entire Scan List will clear since one of its channels has become restricted.

Perform the following steps to create a channel list or scan list:

Step 1. Select display mode.

1. If you are entering a list of channels for basic close and open operation, make sure the instrument is in the channel list display state (see Figure 4-1A) with the following message prompt displayed:

   SELECT CHANNELS

   The Model 7001 powers-up to this state. The SCAN LIST key toggles between the channel list and the scan list.

2. If you are entering a list of channels for scan operation, display the scan list:

   SCAN CHANNELS

Note: If an unwanted list is currently displayed, press CLEAR LIST to clear the display of all listed channels.

Step 2. Enter slot number and card channel.

1. Enter slot number — If the desired channel is on Card 1 (slot 1), press the "1" key on the keypad. If the desired channel is on Card 2 (slot 2), press the "2" key. The separator between slot and channel will automatically be entered after you key in the slot number. For example, if you selected slot 1, the entered channel data will look like this:

```
SELECT CHANNELS 1!
SCAN CHANNELS 1!
```

2. Enter card channel:

   Non-matrix type card — For a non-matrix type card, use the keypad to enter the card channel number. For example, if you entered channel 20 (with slot 1 previously selected), the entered channel data will look like this:

```
SELECT CHANNELS 1!20
SCAN CHANNELS 1!20
```

   Matrix card—For a matrix card, use the keypad to first enter the row number (1 through 4), and then the column number. The separator between row and column will automatically be inserted after you enter the row number. For example, if you entered row 3, column 6 (with slot 2 previously selected), the entered channel data will look like this:

```
SELECT CHANNELS 2!3!6
SCAN CHANNELS 2!3!6
```

NOTE

The Model 7001 can store up to 100 channel patterns in memory locations M1 through M100. The closed channels in any one of these patterns can be entered by simply keying in the memory location using the "M" key on the keypad. For example, assume memory location M1 contains 10 closed channels for a specific slot, enter the channel pattern by simply keying in M1 from the keypad. The entered channel data will look like this:

```
SELECT CHANNELS M
SCAN CHANNELS M1
```

Paragraph 4.5.5 explains how to store channel patterns into memory.

At this point, the entered channel can be cancelled by pressing the left cursor key (◁).

Step 3. Enter channel separator or terminator.

Channel separators are required for multiple channel entries, and a terminator should be used after the last entered channel.

The comma (,) is used to separate channels, and serves to terminate the list. After entering a channel, as explained in Step 2, press the right cursor key (▷) or ENTER to put in the comma separator. Another channel can then be keyed-in. After the last channel in list is keyed-in, use the ENTER key or the right cursor key (▷) to terminate the list. The comma terminator prevents the last entered channel from being cancelled when the left cursor key (◁) is pressed. The following example shows proper format:

```
SELECT CHANNELS 1!1, 1!2, 1!3, 1!4, 1!5, 1!6, 1!7, 1!8, 1!9, 1!10, M1,
SCAN CHANNELS 1!1, 1!2, 1!3, 1!4, 1!5, 1!6, 1!7, 1!8, 1!9, 1!10, M1,
```

The above display indicates that channels 1!1 through 1!10, and the closed channels stored at memory location 1 (M1) are entered.

The hyphen (-) is used to designate a range of channels. After entering the first channel, as explained in Step 2, press the "-" key on the keypad to put in the hyphen, and then key-in the last channel. The following example shows proper format:

```
SELECT CHANNELS 1!1-1!10, M1,
SCAN CHANNELS 1!1-1!10, M1,
```

The above display indicates that channels 1!1 through 1!10, and the closed channels stored at memory location 1 (M1) are entered.

Step 4. Repeat the basic procedure in steps 2 and 3 to enter all required channels.

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Step 5. Edit the entered list as required.

Edit keys are available to make changes to a list. These keys allow you to change channels, delete channels, or insert channels anywhere in the list. When editing, a channel range (i.e. 1!1-1!6) and a memory location (i.e. M1) are treated as single channel entries.

1. Changing a channel — Perform the following steps to change a channel:
   - A. Use the cursor keys to place the cursor at the beginning of the channel entry to be changed.
   - B. Key in the new channel entry, and press the right cursor key (▷) or ENTER to add the comma.
2. Deleting a channel — Perform the following steps to delete a channel:
   - A. Place the cursor at the beginning of the channel to be deleted.
   - B. Press the DELETE key to delete the channel entry.
3. Inserting a channel — Perform the following steps to insert a channel anywhere in the list:
   - A. Position the cursor at the desired location in the list. The channel will be inserted between the selected channel entry and the channel entry before it.
   - B. Press the INSERT key. The following message will be displayed:

     INSERTING ENTRY

   - C. Key in the new channel entry, and press the right cursor key (▷) or ENTER to add the comma.
   - D. Press INSERT a second time to cancel the insert edit function.
4. Deleting all channels — The entire list can be cleared by pressing CLEAR LIST.

Summary of channel list and scan list entry keys:

Keypad:

Number keys — Enter slot and channel numbers (row and column for matrix).

"M" and number keys — Enter memory location of stored channels (i.e. M1).

"-" — Define a range of channels (i.e. 1!1-1!9).

"▷" — Enter channel separator (,).

"◁ and ▷" — After terminating list, use cursor keys to select channel entry to be edited.

ENTER: Enter channel separator (,) and list terminator (,) (i.e 1!1,).

INSERT: Create new channel entry at selected location in the list.

DELETE: Clear selected channel entry.

CLEAR LIST: Clear displayed list.

NOTES

1. When a scan list is modified over the IEEE-488 bus, the displayed scan list will not update until a display state change occurs (i.e., pressing the SCAN LIST key).
2. A channel list is lost after the instrument is turned off.

4.5.3 Closing and opening channels

One of the basic capabilities of the Model 7001 is to close (or open) one or more channels specified by the user. All the specified channels will either close or open at the same time. An exception to this is when the Single Channel mode is enabled (see paragraph 4.8.4). With Single Channel mode enabled, only the lowest numbered channel in the lowest numbered slot will close.

This operation is performed with the instrument in the channel list display state. The instrument powers up to the channel list display state.

The procedure to close and open channels requires that you understand how to enter the channels to be controlled. In general, a channel list is entered using the keypad. The number keys are used to enter slot and channel (row and column for a matrix card). The right cursor key (▷) (or ENTER key) adds a comma (,) which is used as a channel separator and list terminator. The hyphen key (-) is used to define a range of channels. Finally, the "M" key is used to enter closed channels of a channel pattern stored in memory. For details, see paragraph 4.5.2.

Perform the following steps to close and open channels:

NOTE

Before performing any close/open operations, make sure the switching cards you are using are properly configured. The CARD CONFIG MENU is used to configure various aspects of operation for the installed card(s). See paragraph 4.7 for details.

Step 1. Place instrument in channel list display state.

If the Model 7001 is not in the channel list display state, press EXIT and/or SCAN LIST until the following message prompt is displayed:

```
SELECT CHANNELS
```

Step 2. Enter channel list.

Enter the channels to be closed/opened as explained in paragraph 4.5.2. The following example demonstrates proper format:

```
SELECT CHANNELS 1!1, 1!2, 2!1-2!5, M1,
```

The above channel list includes channels 1 and 2 of slot 1, channels 1 through 5 of slot 2, and whatever channel pattern is stored in memory location 1 (M1).

Step 3. Close (or open) listed channels.

Perform the appropriate close/open operation as follows:

1. To close the listed channels, press the CLOSE key. The "dashes" on the channel status display will indicate the closed channels.
2. To open the listed channels that are currently closed, press OPEN. Note that only the listed channels will open. Any channels that are closed, but not included in the list, will not open when OPEN is pressed. To open unlisted channels, you must press OPEN ALL.

Note: The OPEN and CLOSE keys are only functional while in the normal channel display state. The OPEN ALL key is functional at all times no matter what is currently being displayed.

Summary of close/open keys:

CLOSE — Close channels defined in channel list.

OPEN — Open channels defined in channel list.

OPEN ALL — Open all closed channels.

4.5.4 Scanning channels

The Model 7001 can scan through a specified list of channels. The order that the channels are presented in the scan list determine the channel order for the scan.

Scan process (Trigger Model)

The following information describes front panel control of the scan process. The flowchart (Trigger Model) in Figure 4-8 summarizes scan operation from the front panel.

Idle

The instrument is considered to be in the idle state whenever it is not operating within one of the layers of the Trigger Model. The front panel ARM indicator is off when the instrument is in the idle state. While in the idle state, the instrument cannot perform a scan.

From the front panel, the Model 7001 is taken out of the idle state by pressing the STEP key. When not in the idle state (ARM indicator on) the scanning function is considered to be enabled.

A scan can be aborted at any time by pressing the OPEN ALL key. The Model 7001 will return to the idle state.

Once the instrument is taken out of the idle state, operation proceeds into the arm layer of the Trigger Model.

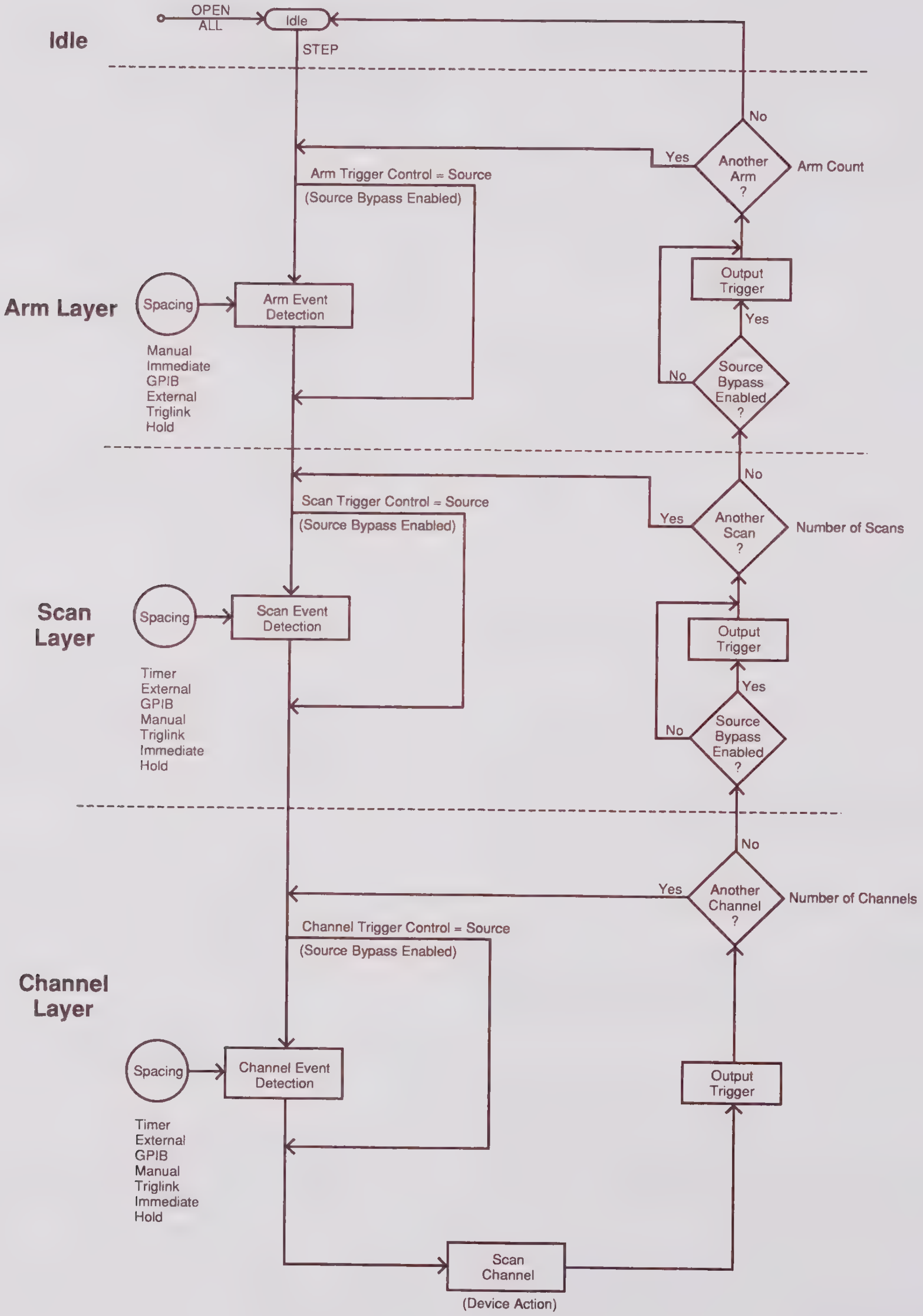
Idle
OPEN
ALL
Idle
STEP
No
Yes
Another
Arm
?
Arm Count
Arm Trigger Control = Source
(Source Bypass Enabled)
Output
Trigger
Yes
Arm Layer
Spacing
Arm Event
Detection
Manual
Immediate
GPIB
External
Triglink
Hold
No
Source
Bypass
Enabled
?
No
Scan Trigger Control = Source
(Source Bypass Enabled)
Yes
Another
Scan
?
Number of Scans
Scan
Layer
Spacing
Scan Event
Detection
Output
Trigger
Yes
Timer
External
GPIB
Manual
Triglink
Immediate
Hold
No
Source
Bypass
Enabled
?
No
Yes
Another
Channel
?
Number of Channels
Channel Trigger Control = Source
(Source Bypass Enabled)
Channel
Layer
Spacing
Channel Event
Detection
Output
Trigger
Timer
External
GPIB
Manual
Triglink
Immediate
Hold
Scan
Channel
(Device Action)

Figure 4-8
Trigger Model (Front panel scan operation)

Arm layer

NOTE

The arm layer is programmed from the SETUP ARM CONTROL menu (see paragraph 4.8.3).

In general, the instrument requires an arm event to allow operation to proceed to the next layer (scan layer). With Immediate arm spacing selected, operation immediately proceeds to the next layer when the instrument is taken out of the idle state. RESET and factory defaults set arm spacing to Immediate. With one of the other arm spacing events selected, the instrument will wait until the appropriate event occurs.

With Manual arm spacing selected, the instrument will wait until the front panel STEP key is pressed. With GPIB arm spacing selected, the instrument will wait until a bus trigger is received (GET or *TRG). With External arm spacing selected, the instrument will wait until an input trigger (via EXTERNAL TRIGGER connector on rear panel) is received. With TrigLink (Trigger Link) arm spacing selected, the instrument will wait until an input trigger is received (via TRIGGER LINK). With Hold arm spacing selected, the instrument will not respond to any of the arm spacing events.

As can be seen in the flowchart, there is a path that allows operation to loop around the programmed spacing event. This path is called the Source Bypass. When the Source Bypass is enabled (Arm Trigger Control set to Source) and External or TrigLink arm spacing is selected, operation will loop around the spacing event on the initial pass through the arm layer. If programmed for another arm (arm count >1), the bypass loop will not be in effect even though it will be enabled. The Source Bypass loop will reset (be in effect) when operation goes into Idle.

Enabling the Source Bypass also enables the Output Trigger in this layer. When operation returns to the arm layer from the scan layer, an output trigger pulse will occur. If TrigLink arm spacing is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line. For all other arm spacing selections, the output trigger pulse will be available at the CHANNEL READY connector. The output trigger for this layer is disabled when the Source Bypass is disabled (Arm Trigger Control set to Acceptor). RESET and factory defaults set Arm Trigger Control to Acceptor.

The instrument can be programmed for additional arms. The arm count can be set to infinity or to a finite value (1 to 9999). RESET and factory defaults set arm count to 1.

After leaving the arm layer, operation proceeds into the scan layer.

Scan layer

NOTE

The scan layer is programmed from the SCAN CONTROL menu (see paragraph 4.8.2).

Operation in the scan layer is similar to operation in the arm layer, except that spacing is controlled by scan events rather than arm events. A timer is available in this layer to control scan spacing. When Timer scan spacing is selected, operation will immediately proceed into the channel layer on the initial pass through the scan layer. Each additional scan (1 to 9999 or infinite) will not occur until the programmed timer interval elapses. The timer can be set to an interval from 1msec to 99999.999 seconds.

The Source Bypass and Output Trigger function in the same manner as the Source Bypass and Output Trigger in the arm layer. The Source Bypass (if enabled) will reset (back in effect) after all programmed scans are completed.

RESET and factory defaults set scan spacing to Immediate, scan count to infinite and Scan Trigger Control to Acceptor.

After leaving the scan layer, operation proceeds into the channel layer.

Channel layer

NOTE

The channel layer is programmed from the CHANNEL CONTROL menu (see paragraphs 4.8.1).

Operation in the channel layer is similar to operation in the scan layer, except that spacing is controlled by channel events rather than scan events, and the Output Trigger is always enabled.

When Timer channel spacing is selected, the first channel will be scanned immediately. Each additional channel is then scanned at a rate determined by the programmed timer interval (1msec to 99999.999 seconds). With Immediate channel spacing selected, channels will be scanned immediately. The scan rate will primarily be determined by the internally set relay settling time and any user programmed delay (see paragraph 4.7.4). For Model 701X series cards, the internal relay settling time is 6msec; 3msec after the relay closes and 3msec after the relay opens. The user programmed delay is in addition to the relay settling time.

The device action (scan channel) for each channel includes:

1. If not the first channel in the scan, open the previous channel and wait for the internal settling delay to time out.
2. Close the next channel in the scan and wait for the internal settling delay to time out.
3. Wait for the user programmed delay (0 to 99999.999 seconds) to time out.

The Source Bypass (if enabled) will reset (be in effect) after the programmed number of channels are scanned.

The Output Trigger for the channel layer is always enabled and occurs after each channel is scanned (device action). For all channel spacing selections, except TrigLink, the TTL Output Trigger Pulse is available at the CHANNEL READY connector. For TrigLink channel spacing, the Output Trigger functions as follows:

1. If the asynchronous Trigger Link mode is selected, the TTL Output Trigger pulse will be available on the programmed Trigger Link output line.
2. If the semi-synchronous Trigger Link mode is selected and the Source Bypass is disabled (Channel Trigger Control set for Acceptor), the Trigger Link line will be released (goes high).
3. If the semi-synchronous Trigger Link mode is selected, and the Source Bypass is enabled (Channel Trigger Control set for Source), the Trigger Link line will be pulled down low and then released.

See paragraph 4.11 for details on the Trigger Link.

RESET and factory defaults set channel spacing to Manual, channel count to the scan list length, and Channel Trigger Control to Source.

Scan list

Scanning channels requires that you understand how to enter channels for the scan list. In general, a channel is entered using the keypad. The number keys are used to enter the slot and channel (row and column for a matrix card). The right cursor key (▷) (or ENTER key) adds a comma (,) which is used as a channel separator or list terminator. The hyphen key (-) is used to define a range of channels. Finally, the "M" key is used to enter a channel pattern stored in memory. For details, see paragraph 4.5.2.

When a channel pattern is scanned, the closed switches in the pattern will close and remain closed for the duration of the scan. A channel pattern is useful for supplying bias voltages in a test system.

Scan procedure

Perform the following steps to scan channels:

NOTE

Before performing scan operation, make sure the switching cards that you are using are properly configured. The CARD CONFIG menu is used to configure various aspects of operation for the installed card(s). See paragraph 4.7 for details.

Step 1. Press OPEN ALL.

Before configuring a scan, you should place the Model 7001 in the idle state by pressing OPEN ALL. This will stop any scan that is currently in process, open all channels, and place the Model 7001 in the idle state.

Step 2. Create a scan list.

With the instrument in the scan list display state, enter the channels to be scanned as explained in paragraph 4.5.2. The following example demonstrates proper format:

```
SCAN CHANNELS 1!1, 1!2, 2!1-2!5, M1,
```

The above scan list includes channels 1 and 2 of slot 1, channels 1 through 5 of slot 2, and whatever closed channels are stored in memory location 1. Channels will be scanned in the order that they are presented in this list. M1 will be treated as a single channel. If for example, M1 is made up of two closed channels, those two channels will close and remain closed when M1 is scanned.

At the conclusion of a scan, the last channel in the list will remain closed. If you wish to open the last channel, specify a memory location that has no closed channels as the last entry in the scan list. For example, if in the above scan list M1 has no closed channels, Channel 2!5 will open at the conclusion of a single scan.

Step 3. Configure the Channel Layer of the scan.

The channel layer is programmed from the CHAN CONTROL menu of the CONFIGURE SCAN menu. Detailed information on using the CHANNEL CONTROL menu is provided in paragraph 4.8.1 and Table 4-6.

The following procedure summarizes the steps to configure the channel layer:

1. From the CONFIGURE SCAN menu, select CHAN CONTROL.
2. From the CHANNEL CONTROL menu, select CHANNEL-SPACING.
3. From the SELECT CHAN SPACING menu, select one of the following events (or IMMEDIATE) to control the process of scanning channels:
   A. TIMER — Use to set a time interval (1msec to 99999.999 seconds) between channels.
   B. EXTERNAL — With this selection, external triggers control channel spacing. Each trigger applied to the rear panel EXTERNAL TRIGGER connector will select the next channel of the scan.
   C. GPIB — With this selection, bus triggers (GET or *TRG) control channel spacing. Each bus trigger received by the Model 7001 will select the next channel of the scan.
   D. MANUAL — With this selection, the front panel STEP key is used to control channel spacing. Each press of the STEP key will select the next channel of the scan.
   E. TRIGLINK — With this selection, triggers received over the Trigger Link will control channel spacing. Each trigger will select the next channel in the scan.
   F. IMMEDIATE — With this selection, events are not used to control channel spacing. Only the time delay for relay settling and an optional DELAY (see paragraph 4.7) programmed by the user affect channel spacing in the scan.
4. From the CHANNEL CONTROL menu, select NUMBER OF CHANS.
5. From the NUMBER OF CHANNELS menu, select one of following items to specify the number of channels to scan:
   A. USE SCANLIST LENGTH — With this selection, a single scan of all the channels in the scan list will occur for every programmed scan (scan count).
   B. CHAN-COUNT — With this selection, you have the following two options for CHANNEL COUNT:
      a. INFINITE — With this count selection, the channel scan will repeat indefinitely.
      b. ENTER-CHAN-COUNT — Use this selection to define the number of channels (1 to 9999) to scan. The channel scan wraps around and continues to satisfy a channel count that exceeds the scan list length.

Step 4. Configure the Scan Layer of the scan.

The scan layer is programmed from the SCAN CONTROL menu of the CONFIGURE SCAN menu. Detailed information on using the SCAN CONTROL menu is provided in paragraph 4.8.2.

The following procedure summarizes the steps to configure the scan layer:

1. From the CONFIGURE SCAN menu, select SCAN CONTROL.
2. From the SCAN CONTROL menu, select SCAN SPACING.
3. From the SELECT SCAN SPACING menu, select one of the following events (or IMMEDIATE) to control scan spacing:
   A. TIMER — Use to set a time interval (1msec to 99999.999 seconds) between scans.
   B. EXTERNAL — With this selection, external triggers control scan spacing. A trigger applied to the rear panel EXTERNAL TRIGGER connector will allow operation to proceed to the channel layer.
   C. GPIB — With this selection, bus triggers (GET or *TRG) control scan spacing. A bus trigger received by the Model 7001 will allow operation to proceed to the channel layer.
   D. MANUAL — With this selection, the front panel STEP key is used to control scan spacing. Each press of the STEP key will allow operation to proceed to the channel layer.
   E. TRIGLINK — With this selection, triggers received over the Trigger Link will control scan spacing. A trigger will allow operation to proceed to the channel layer.
   F. IMMEDIATE — With this selection, events are not used to control scan spacing. Operation will proceed immediately to the channel layer.
4. From the SCAN CONTROL menu, select NUMBER-OF-SCANS.
5. From the NUMBER OF SCANS menu, select one of following items to specify the number of scans to be performed:
   A. INFINITE — With this selection, the scan will repeat indefinitely.
   B. ENTER-SCAN-COUNT — Use this selection to define the number of scans (1 to 9999) to be performed.

Step 5. Configure the Arm Layer of the scan.

The arm layer is programmed from the ARM CONTROL menu of the CONFIGURE SCAN menu. Detailed information on using the ARM CONTROL menu is provided in paragraph 4.8.3.

The following procedure summarizes the steps to configure the arm layer:

1. From the CONFIGURE SCAN menu, select ARM CONTROL.
2. From the SETUP ARM CONTROL menu, select ARM SPACING.
3. From the SELECT ARM SPACING menu, select one of the following events (or IMMEDIATE) to control the interval between arms:
   A. MANUAL — With this selection, the front panel STEP key is used to control arm spacing. Pressing the STEP key will allow operation to proceed to the scan layer.
   B. IMMEDIATE — With this selection, events are not used to control arm spacing. Operation will proceed immediately to the scan layer.
   C. GPIB — With this selection, bus triggers (GET or *TRG) control arm spacing. A bus trigger received by the Model 7001 will allow operation to proceed to the scan layer.
   D. EXTERNAL — With this selection, external triggers control arm spacing. A trigger applied to the rear panel EXTERNAL TRIGGER connector will allow operation to proceed to the scan layer.
   E. TRIGLINK — With this selection, triggers received over the Trigger Link will control arm spacing. A trigger will allow operation to proceed to the scan layer.
4. From the SETUP ARM CONTROL menu, select ARM COUNT.
5. From the ARM-COUNT menu, select one of following items to specify the number of arms to be performed:
   A. INFINITE — With this selection, the number of arms is infinite.
   B. ENTER-ARM-COUNT — Use this selection to define the number of arms (1 to 9999) to be performed.

Step 6. Start the scan.

NOTE

To view the scan, exit from the CONFIGURE SCAN menu by pressing EXIT until the instrument returns to the channel status display state. If needed, press SCAN LIST to display the channels to be scanned.

Step 1 of this procedure placed the Model 7001 in the idle state. In this idle state, a scan cannot be performed. The Model 7001 is taken out of the idle state by pressing the STEP key.

Once out of the idle state, the scan is considered enabled. The scan will proceed according to how the three layers are programmed. If Immediate spacing is selected, operation will pass immediately into the next layer. If spacing is programmed for a particular event, operation will not pass into the next layer until the event occurs.

Scanning examples:

The following examples assume two scans of a two-channel scan list. All events in these examples can be substituted by the STEP key. For example, if the instrument is waiting for an EXTERNAL trigger event, you can instead press STEP to provide the event.

Example 1:

ARM SPACING = IMMEDIATE

SCAN SPACING = TIMER, EXTERNAL, GPIB, MANUAL or TRIGLINK

CHANNEL SPACING = TIMER, EXTERNAL, GPIB, MANUAL or TRIGLINK

1. Press OPEN ALL to open all channels and place the Model 7001 in the idle state.
2. Press STEP to take the 7001 out of the idle state (ARM indicator turns on).
3. The first scan spacing event will pass operation into the channel layer.
4. The first channel spacing event will scan the first channel in the scan list.
5. The next channel spacing event will scan the second channel.
6. The next scan spacing event will pass operation back into the channel layer.
7. The next channel spacing event will scan the first channel.
8. The next channel spacing event will scan the second channel and disarm (idle) the scan.

Example 2:

ARM SPACING = IMMEDIATE

SCAN SPACING = IMMEDIATE

CHANNEL SPACING = TIMER, EXTERNAL, GPIB, MANUAL or TRIGLINK

1. Press OPEN ALL to open all channels and place the Model 7001 in the idle state.
2. Press STEP to take the 7001 out of idle state, and operation into the channel layer.
3. The first channel spacing event will scan the first channel.
4. The next channel spacing event will scan the second channel.
5. Operation passes automatically back into the channel layer since IMMEDIATE scan spacing is selected.
6. The next channel spacing event will scan the first channel.
7. The next channel spacing event will scan the second channel and disarm (idle) the scan.

Example 3:

ARM SPACING = MANUAL, GPIB, EXTERNAL or TRIGLINK

SCAN SPACING = TIMER, EXTERNAL, GPIB, MANUAL or TRIGLINK

CHANNEL SPACING = TIMER, EXTERNAL, GPIB, MANUAL or TRIGLINK

1. Press OPEN ALL to open all channels and place the Model 7001 in the idle state.
2. Press STEP to take the 7001 out of the idle state.
3. The arm spacing event allows operation to pass into the scan layer.
4. The first scan spacing event passes operation into the channel layer.

5. The first channel spacing event will scan the first channel in the scan list.
6. The next channel spacing event will scan the second channel.
7. The next scan spacing event will pass operation back into the channel layer.
8. The next channel spacing event will scan the first channel.
9. The next channel spacing event will scan the second channel and disarm (idle) the scanner.

Example 4:

ARM SPACING = MANUAL, GPIB, EXTERNAL or TRIGLINK

SCAN SPACING = IMMEDIATE

CHANNEL SPACING = TIMER, EXTERNAL, GPIB, MANUAL or TRIGLINK

1. Press OPEN ALL to open all channels and place the Model 7001 in the idle state.
2. Press STEP to take the 7001 out of the idle state.
3. The arm spacing event allows operation to pass into the scan layer.
4. Operation passes immediately into the channel layer since IMMEDIATE scan spacing is selected.
5. The first channel spacing event will scan the first channel in the scan list.
6. The next channel spacing event will select the second channel.
7. Operation passes automatically back into the channel layer since IMMEDIATE scan spacing is selected.
8. The next channel spacing event will select the first channel.
9. The next channel spacing event will select the second channel and disarm (idle) the scan.

Scanning notes:

1. The STEP key is always functional during a scan and can be used to provide a spacing event. For example, if programmed for TIMER channel spacing, the STEP key can also be used to select the next channel.
2. Forbidden Channels cannot be entered into the scan list.
3. With Single Channel enabled, only the lowest numbered channel in a memory location (i.e. M1) will close when selected.
4. Card Pair is functional during a scan. The channels included in the scan list and the corresponding channels for the other slot will be scanned.

Summary of scan keys:

OPEN ALL — Use to stop a scan, open all channels, and place the Model 7001 in the scan idle state.

STEP—Use to take the Model 7001 out of the idle state; and also, use to manually step through a scan.

4.5.5 Storing channel patterns (STORE and RECALL)

Any displayed channel pattern can be stored in memory locations M1 through M100. A channel pattern is simply a pattern of open and closed channels.

Channel Patterns are not lost (cleared) when the instrument is turned off. However, a Channel Pattern is cleared if any of the following events occur:

1. A closed channel in the Channel Pattern becomes unavailable. A channel can become unavailable by changing a slot assignment (Card TYPE) or by changing to a pole mode that reduces the number of available channels.
2. A closed channel in the Channel Pattern becomes restricted. A channel becomes restricted by adding it to the restricted channel list.

The following examples demonstrate how a Channel Pattern is lost:

1. Assume a Channel Pattern includes channel 1!21 as a closed channel and the assignment for slot 1 is changed to a multiplexer card that has only 20 channels. Since channel 1!21 no longer exits, the Channel Pattern is cleared.
2. Assume a Channel Pattern includes channel 1!1 as a closed channel and the assignment for slot 1 is changed to a matrix card. Since channel 1!1 is an incorrect format for a matrix card, it no longer exists. The Channel Pattern is cleared.

3. Assume a Channel Pattern includes channel 1!21 and the slot (slot 1) is configured for 2-pole operation. Changing the pole-mode of slot 1 to 4-pole operation makes channel 1!21 unavailable and clears the Channel Pattern.
4. Assume a Channel Pattern includes channel 1!1. If channel 1!1 is then added to the restricted channel list, the Channel Pattern is cleared.
5. Assume a Channel Pattern includes channel 1!1 and Card Pair is enabled. Note that with card pair enabled, channel 2!1 is then added as a restricted channel, the Channel Pattern will clear since one of its channels has become restricted.

Note that if a Channel pattern is included in the Scan List (i.e. M1) and the Channel Pattern is lost (as explained above), then the Scan List will also be lost (see paragraph 4.5.2).

Storing channel patterns

Perform the following steps to store a channel pattern in a memory location:

Step 1. Place instrument in channel list display state.

```
SELECT CHANNELS
```

Step 2. If there are any undesired channels currently closed, press OPEN ALL to open them.

Step 3. Enter channels that you wish to close.

Channel list entry is explained in paragraph 4.5.2. The following example demonstrates proper format:

```
SELECT CHANNELS 1!1, 1!2, 2!4,
```

The above channel list includes channels 1 and 2 of slot 1, and channel 4 of slot 2.

Step 4. Close channels.

Close the channels specified in the list by pressing CLOSE.

Step 5. Store the displayed channel pattern.

Perform the following steps to store the channel pattern:

1. Press STORE. The following typical message will be displayed:

```
STORE CHANS AT #001
```

The above message indicates that the channel pattern will be stored at memory location M1.

NOTE

You can exit from the Store mode without storing the channel pattern by pressing EXIT. The instrument will return to the channel list display state.

2. If you wish to store the channel pattern at the displayed memory location, proceed to step 3. Otherwise, use the cursor keys (◁ and ▷) and the number keys to key in the desired memory location (001 to 100).
3. To store the channel pattern at the displayed memory location, press ENTER. The instrument will return to the channel status display state.

Recalling channel patterns

There are two ways to recall a channel pattern. One way is to immediately access the channel pattern from memory using RECALL. The open/close channel pattern will be displayed on the Model 7001 indicating the actual state of each channel. The other way is to specify the memory location (i.e. M1) of the channel pattern in the channel list and/or scan list. The closed channels in the channel pattern will close when that memory location is closed or scanned.

Recalling a channel pattern using RECALL

Perform the following steps to use RECALL:

1. While in channel list or scan list display states, press RECALL to display the following typical message:

```
RECALL CHANS AT #001
```

The above message indicates that the channel pattern will be recalled from memory location M1.

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NOTE

You can exit from the Recall mode without recalling the channel pattern by pressing EXIT. The instrument will return to the channel list display state.

2. If you wish to recall the channel pattern from the displayed memory location, proceed to step 3. Otherwise, use the cursor keys (◁ and ▷) and the number keys to key in the desired memory location (001 to 100).
3. To recall the channel pattern from the displayed memory location, press ENTER. The instrument will return to the channel status display state and display the recalled channel pattern.

CAUTION

As soon as the display updates to the selected channel pattern, the corresponding relays on the card will also update. Thus, make sure you want to energize the card relays before recalling a channel pattern.

Recalling a channel pattern via channel list and/or scan list

A channel pattern can be recalled by specifying the memory location in a channel list and/or scan list. For example, assume a channel pattern that has Channels 2!11 and 2!36 closed is stored at memory location M10. Also assume that M10 is included in the following channel list:

```
SELECT CHANNELS 1!1, 1!4, M10,
```

When CLOSE is pressed with the above channel list displayed, Channels 1!1, 1!4, 2!11 and 2!36 will close.

Now assume the M10 is included in the following scan list:

```
SCAN CHANNELS 1!1, 1!4, M10, 1!6,
```

When M10 is selected in the scan, both Channels 2!11 and 2!36 will be closed at the same time and will remain closed when channel 1!6 is scanned.

4.6 MENU

Various instrument operations to configure the Model 7001 are performed using the front panel MENU. The MENU structure is shown and summarized in Table 4-2.

General rules to use MENU

1. The MAIN MENU is displayed by placing the instrument in the normal channel display state, and then pressing the MENU key. If already in the menu structure, the MAIN MENU can be displayed by pressing and releasing the EXIT key until the MAIN MENU selections are displayed (see next rule). The MAIN MENU selections are shown as follows:

```
MAIN MENU
SAVESETUP  GPIB  DIGITAL-I/O▶
◀ TEST  LANGUAGE  GENERAL
```

2. Pressing the EXIT key causes the display to back up to the previous menu level. Also, keyed-in parameter changes are ignored if an EXIT is performed. When the MAIN MENU is displayed, pressing EXIT or MENU will disable MENU.
3. The position of the cursor is denoted by the blinking menu selection or parameter. The cursor is moved from one item to the next using the cursor keys (◁ and ▷).
4. A displayed arrow (◀ or ▶) indicates that there is more information or additional menu items to select from. When "▶" is displayed, use the ▷ cursor key to display the additional message(s); and conversely, when "◀" is displayed, use the ◁ cursor key.
5. A numeric parameter is keyed in by placing the cursor on the digit to be changed, and pressing the appropriate key on the keypad. After keying in a number, the cursor will move to the next digit to the right.
6. A parameter change is only executed when the ENTER key is pressed.
7. ENTERing an invalid parameter generates an error and ignores the entry.
8. The INFO key can be used anywhere in the menu structure to display helpful information messages concerning operation. To cancel an information message, press EXIT or INFO a second time.

Table 4-2
MENU structure

Menu item	Description
SAVESETUP	Setup Menu:
SAVE	Save setup at a memory location (up to 10).
RESTORE	Return 7001 to setup stored at a memory location.
PWRON	Power-on Menu:
FACTORY DEFAULT	Power-on to factory default setup conditions.
USER SETUP	Power-on to setup stored at a memory location.
RESET	Return 7001 to original power-on setup.
GPIB	GPIB Setup Menu:
ADDRESS	Check/change IEEE-488 address.
STATUS	Display IEEE-488 status byte.
DIGITAL-I/O	Digital I/O Menu:
OUTPUT-STATUS	Check/change states of digital output channels.
OUTPUT-POLARITY	Check/change polarity of digital output port.
INPUT-STATUS	Read digital input channel.
TEST	Self-Test Menu:
BUILT-IN TESTS	Test Digital Board:
AUTO	Run all tests automatically
MANUAL	Select tests to run
DISPLAY TESTS	Test Display Board:
KEYS	Verify operation of front panel keys
PATTERNS	Verify operation of display
CHAR SET	Display ASCII character set.
LANGUAGE	Choose 7001 Language:
ENGLISH	Display messages in English.
GERMAN	Display messages in German.
FRENCH	Display messages in French.
GENERAL	General Menu:
SERIAL #	Displays serial number, SCPI version, and software revision.
STATUS-MESSAGES	Enables/disables status message mode.
BREAK BEFORE MAKE	Enables/disables Break-Before-Make.

4.6.1 SAVESETUP

The SAVESETUP menu is used for the following operations:

- Save the current setup conditions in memory for future recall. Up to 10 setups can be saved in memory.
- Restore the instrument to setup conditions stored in memory.
- Setup the power-on (PWRON) configuration. The instrument can be set to power-on to the factory default setup conditions, or power-on to the setup conditions stored at a specified memory location.
- Reset the instrument to the original power-on setup conditions (see Table 4-3).

Perform the following steps to display the SAVESETUP menu:

1. Display the MAIN MENU (see paragraph 4.6, General rule #1).
2. Use the cursor keys (◁ and ▷) to place the cursor on SAVESETUP, and press ENTER to access the following menu:

```
SETUP MENU
SAVE   RESTORE   PWRON   RESET
```

SAVE — Use this menu item to save the current setup conditions in memory at a specified memory location. To select SAVE, place the cursor on SAVE and press ENTER. The following typical message will be displayed:

```
SAVE SETUP #0 (0-9)
```

1. To save the current setup at the displayed memory location, press ENTER. The instrument will return to the SETUP MENU.
2. To save the current setup to a different memory location, key in a value (0 to 9) and press ENTER. The instrument will return to the SETUP MENU.

RESTORE — Use this menu item to return the instrument to the setup conditions that are stored in memory at a specified memory location. To select RESTORE, place the cursor on RESTORE and press ENTER. The following typical message will be displayed:

```
RESTORE SETUP #0
```

1. To restore the instrument to the setup conditions stored at the displayed memory location, press ENTER. The instrument will return to the SETUP MENU.
2. To restore the instrument to the setup conditions stored at a different memory location, key in the memory location (0 to 9) and press ENTER. The instrument will return to the SETUP MENU.

PWRON — Use this menu item to select the setup conditions that the instrument will power-on to. To select the PWRON menu item, place the cursor on PWRON and press ENTER. The following menu will be displayed:

```
SET POWER-ON DEFAULT
FACTORY-DEFAULT   USER-SETUP
```

FACTORY DEFAULT — With this selection, the instrument will return to the factory default conditions (see Table 4-3) the next time it is turned on. To select the FACTORY-DEFAULT menu item, place the cursor on FACTORY-DEFAULT and press ENTER. The instrument will return to the SETUP MENU.

USER SETUP — Using this selection, the instrument will power-on to the setup conditions saved at a specified memory location. To select USER-SETUP, place the cursor on USER-SETUP and press ENTER. The following typical message will then be displayed:

```
PWRON DEFAULT = #0
```

1. To power-on to the setup conditions stored at the displayed memory location, press ENTER. The instrument will return to the SETUP MENU.
2. To power-on to setup conditions stored at a different memory location, key in the memory location (0 to 9) and press ENTER. The instrument will return to the SETUP MENU.

RESET — Use this menu item to reset the instrument to the RESET default setup conditions (see Table 4-3). To select RESET, place the cursor on RESET and press ENTER. The following message will be displayed:

```
RESETTING INSTRUMENT
```

Press ENTER to display:

```
RESET COMPLETE
```

Press ENTER to return to the SETUP MENU.

Table 4-3
Default conditions

Item	Factory default	RESET
Channel status	All open	All open
Channel list	Cleared	No change
Scan list	No change	No change
GPIB address	No change	No change
Digital I/O output level	High	High
Language	No change	No change
Status messages	Off	Off
# of poles	No change	No change
Card pair	Off	Off
Delay	0 sec	0 sec
Channel spacing	Manual (STEP key)	Manual (STEP key)
Number of channels	Scan list length	Scan list length
Channel trigger control	Source	Source
Scan spacing	Immediate	Immediate
Number of scans	Infinite	Infinite
Scan trigger control	Acceptor	Acceptor
Arm spacing	Immediate	Immediate
Arm count	1	1
Arm trigger control	Acceptor	Acceptor
Single channel	Off	Off
Restricted channels	No change	No change
Break Before Make	On	On

Note: "No change" indicates that the currently set conditions are not affected.

4.6.2 GPIB

The GPIB menu is used for the following operations:

- Check and/or change the address of the IEEE-488 bus.
- Display the status byte of the IEEE-488 bus.

Perform the following steps to display the GPIB menu:

1. Display the MAIN MENU (see paragraph 4.6, General rule #1).
2. Use the cursor keys (◁ and ▷) to place the cursor on GPIB, and press ENTER to display the following menu:

```
GPIB SETUP MENU
ADDRESS   STATUS
```

ADDRESS — Use this menu item to check and/or change the IEEE-488 address. At the factory the address is set to 7, but can be changed to any value from 0 to 30. To select ADDRESS, place the cursor on ADDRESS and press ENTER. If the address is currently set to 7, the following message will be displayed:

```
ADDRESS = 07 (0-30)
```

1. To retain the displayed address, press ENTER or EXIT. The instrument will return to the GPIB SETUP MENU.
2. To change the address, simply key in a valid value (0 to 30) and press ENTER. The instrument will return to the GPIB SETUP MENU.

STATUS — Use this menu item to display the IEEE-488 status byte. Refer to Section 4 (IEEE-488 Reference) for information on the status byte. To select STATUS, place the cursor on STATUS and press ENTER. If for example, all bits of the status byte are reset to zero, it will be displayed as follows:

```
    SHOW STATUS BYTE
    EVA = 0   QSB = 0   MAV = 0   ESB = 0 ▶
◀   MSS = 0   OSB = 0
```

When finished viewing the status byte, press either ENTER or EXIT. The instrument will return to the GPIB SETUP MENU.

4.6.3 DIGITAL-I/O

The DIGITAL-I/O menu is used for the following operations:

- Check and/or change the OUTPUT-STATUS (on or off) of the four digital output channels.
- Check and/or change the OUTPUT-POLARITY of the digital output port. Polarity can be active-high (on = +5V) or active-low (on = 0V).
- Check the INPUT-STATUS (on or off) of the single digital input channel.

NOTE

The digital output port uses default levels of 0V and +5V. However, a user supplied voltage level of up to 30V can be used instead of the 5V level (see paragraph 4.9.1).

Perform the following steps to display the DIGITAL-I/O MENU:

1. Display the MAIN MENU (see paragraph 4.6, General rule #1).
2. Use the cursor keys (◁ and ▷) to place the cursor on DIGITAL-I/O and press ENTER to access the following menu:

```
DIGITAL-I/O MENU
OUTPUT-STATUS   OUTPUT-POLARITY ▶
◀ INPUT-STATUS
```

OUTPUT-STATUS — Use this menu item to check and/or change the state (on or off) of the four digital output channels. The actual level of an "on" channel is determined by the polarity, which is controlled by the next menu item (OUTPUT-POLARITY). To select OUTPUT-STATUS, place the cursor on OUTPUT-STATUS and press ENTER. If for example, all the digital output channels are off, the following message will be displayed:

```
DIGITAL OUTPUT LINES
1 = OFF   2 = OFF   3 = OFF   4 = OFF
```

1. To retain the displayed states of the output channels, press ENTER or EXIT. The instrument will return to the DIGITAL-I/O MENU.
2. To change the state of one or more digital output channels, perform the following steps:
   A. Position the cursor at the channel that you wish to change.
   B. Press any one of the keys on the keypad. These keys simple toggle between "ON" and "OFF".
   C. Repeat steps A and B for each channel that you wish to change.
   D. With the desired states displayed, press ENTER. The instrument will return to the DIGITAL-I/O MENU.

OUTPUT-POLARITY — Use this menu item to check and/or change the polarity of the digital output port. The polarity of each channel can be active-high (ON = +5V) or active low (ON = 0V). To select OUTPUT-POLARITY, place the cursor on OUTPUT-POLARITY and press ENTER. The following message will be displayed:

```
SELECT OUTPUT LINE
TTL1       TTL2       TTL3       TTL4
```

1. Place the cursor on the appropriate channel and press ENTER. A message indicating the polarity of the selected channel will be displayed. For example:

   ```
   TTL1 LOGIC SENSE
   ACTIVE-HIGH          ACTIVE-LOW
   ```

   Cursor position will indicate the polarity of the channel.
2. To retain the currently selected polarity, press ENTER or EXIT. The display will return to the SELECT OUTPUT LINE MENU.
3. To change polarity, place the cursor on the alternate selection using the cursor keys (◁ or ▷) and press ENTER. The instrument will return to the SELECT OUTPUT LINE MENU.

4. When finished, press EXIT to return to the DIGITAL I/O MENU.

INPUT-STATUS — Use this menu item to read (on or off) the digital input channel. Polarity is fixed at active-high (ON = 5V).

To select INPUT-STATUS, place the cursor on INPUT-STATUS and press ENTER. If for example, the digital input channel is "on", the following message will be displayed:

DIGITAL INPUT LINE
Status = ON

Press ENTER or EXIT to return the instrument to the Digital I/O Menu.

4.6.4 TEST

The TEST menu is to be used as a diagnostic tool to isolate problems with the Model 7001. Refer to Section 7 Maintenance for information on using these test procedures.

4.6.5 LANGUAGE

The LANGUAGE menu is used to change the language for display messages. Language selections include:

- Display messages in ENGLISH.
- Display messages in GERMAN.
- Display messages in FRENCH.

Perform the following steps to change the language of menu display messages:

1. Display the MAIN MENU (see paragraph 4.6, General rule #1).
2. Use the cursor keys (◁ and ▷) to place the cursor on LANGUAGE and press ENTER. The following language menu selections will be displayed:

CHOOSE MENU LANGUAGE
ENGLISH GERMAN FRENCH

The cursor will be located on the currently selected language. Note that if a language other than English is currently selected, the menu will be displayed in the selected language.

3. To retain the currently selected language, press EXIT or ENTER. The display will return to the MAIN MENU.
4. To select one of the other languages, place the cursor on the desired language selection and press ENTER. The instrument will return to the MAIN MENU.

Note: The selected language becomes the power-up default.

4.6.6 GENERAL

The GENERAL MENU is used for the following operations:

- Serial # of the Model 7001.
- SCPI version control number.
- Software revision level installed in the Model 7001.
- Select the Status Message Mode.

Perform the following steps to display the GENERAL MENU:

1. Display the MAIN MENU (see General Rule #1, paragraph 4.6).
2. Use the cursor keys (◁ and ▷) to place the cursor on GENERAL and press ENTER. The following menu will be displayed:

GENERAL MENU
SERIAL # STATUS-MESSAGES

SERIAL # — To display the serial number, SCPI version and software revision level of the instrument, place the cursor on SERIAL # and press ENTER. The following information will be displayed:

Serial #XXXXXX
SCPI version #XXX.X software rev AXX/AYY

where; AXX is the software revision of the main CPU.
AYY is the software revision of the display CPU.

When finished, press ENTER or EXIT to return to the GENERAL MENU.

STATUS MESSAGES—This selection is used to enable or disable the status message mode. When enabled, status messages will be displayed to identify specific operations that are performed. Place the cursor on STATUS-MESSAGES and press ENTER. The following message will be displayed:

```
STATUS MESSAGES
OFF   ON
```

Place the cursor on the desired state (on or off) and press ENTER. The instrument will return to the GENERAL MENU.

BREAK-BEFORE-MAKE—This selection is used to enable or disable Break-Before-Make. When enabled, the previous channel will open before the next channel closes during a scan. This ensures that two scanned channels will not be closed at the same time. When recalling a channel pattern from memory, all other channels will open before the channels in the pattern close.

When disabled, break-before-make is no longer ensured. During a scan, this could result in two channels closed momentarily at the same time. When recalling a channel pattern, the channels in the pattern could close before the previous channels open.

Break-Before-Make incorporates a delay to make sure that a channel(s) opens before the nect channel(s) closes. If Break-Before-Make is not necessary for your test system, you can increase scanning speed by disabling it.

Place the curor on BREAK-BEFORE-MAKE and press ENTER to display the following selections:

```
BREAK BEFORE MAKE
ON   OFF
```

Cursor position indicates the current state of Break-Before-Make.

Place the cursor on the desired state and press ENTER. The instrument will retrun to the GENERAL MENU.

NOTE

When finsihed with the GENERAL MENU, use EXIT to back out of the menu structure.

4.7 CARD CONFIG

Various operations to configure the slots of the mainframe are performed from the CARD CONFIG MENU. The menu structure is shown and summarized in Table 4-4.

General rules to use CARD CONFIG MENU:

1. The CARD CONFIG MENU is displayed by placing the instrument in the channel status display state, and then pressing the CARD CONFIGURATION key. If already in the menu structure, the CARD CONFIG MENU can be displayed by pressing and releasing the EXIT key until the CARD CONFIG MENU selections are displayed (see next rule). The CARD CONFIG MENU selections are shown as follows:

```
CARD CONFIG MENU
TYPE   #-OF-POLES   CARD-PAIR ▶
◀ DELAY   READ-I/O-CARD
```

2. The EXIT key causes the display to back up to the previous menu level. Also, keyed-in parameter changes are ignored if an EXIT is performed. When the CARD CONFIG MENU is displayed, pressing EXIT will disable card configuration.
3. The position of the cursor is denoted by the blinking menu selection or parameter. The cursor is moved from one item to the next using the cursor keys (◁ and ▷).
4. A displayed arrow (◀ or ▶) indicates that there is more information or additional menu items to select from. When "▶" is displayed, use the ▷ cursor key to display the additional message(s);

and conversely, when "◀ " is displayed, use the ◁ cursor key.

5. A numeric parameter is keyed in by placing the cursor on the digit to be changed, and pressing the appropriate key on the keypad. After keying in a number, the cursor will move to the next digit to the right.
6. A parameter change is only executed when the ENTER key is pressed.
7. ENTERing an invalid parameter generates an error and ignores the entry
8. The INFO key can be used anywhere in the menu structure to display helpful information messages concerning operation. To cancel an information message, press EXIT or INFO a second time.

4.7.1 TYPE

Use the TYPE feature to assign a model number to each non-701X series card installed in the mainframe. This menu selection also allows you to assign a slot to operate as a simulator. By assigning a slot the value 9990, the mainframe will operate as if a 40 channel multiplexer card is installed. If you assign a slot the value 9991, the mainframe will operate as if a 4 x 10 matrix card is installed in that slot. These simulators allow you to develop a test program even though the card is not installed in the mainframe.

The TYPE menu selection displays an assignment message for each slot. These messages were determined by the Model 7001 mainframe during its power-up sequence and is explained in paragraph 4.2.3. In general, the Model 7001 mainframe detects (on power-up) Model 701X series cards that are installed. All other type cards are not detected and thus, the slot must be assigned the appropriate model number by the user. This user assigned model number is "remembered" by the mainframe after it is turned off. However, if the mainframe detects a 701X series card in the slot on the subsequent power-up, it disregards the model number assigned by the user and assigns the model number of the 701X series card to the slot. You can use Table 4-5 to interpret the displayed messages for TYPE.

Each used slot must be assigned the correct model number (either automatically by the mainframe for 701X series cards or manually by the user) in order for the mainframe to operate correctly. The model number assignment automatically determines the settling time for the relays.

Changing a slot assignment (Card TYPE) could make a channel that is currently included in the Scan List and/or a Channel Pattern unavailable. The unavailable channel causes the Scan List and/or the affected Channel Pattern to clear (see paragraphs 4.5.2 and 4.5.5 for details).

Table 4-4
CARD CONFIG MENU structure

Menu item	Description
TYPE SLOT-1 SLOT-2	Set Card Type: Assign model number to card in slot 1. Assign model number to card in slot 2.
#-OF-POLES SLOT-1 SLOT-2	Select # Of Poles: Select pole mode for card in slot 1. Select pole mode for card in slot 2.
CARD-PAIR	Enable or disable Card Pair.
DELAY SLOT-1 SLOT-2	Set Delay For: Set delay for card in slot 1. Set delay for card in slot 2.
READ-I/O-CARD	Identify I/O Cards.

Table 4-5
TYPE assignments

Assignment message		Interpretation*
SLOT-1 CARD:	701X**	701X series card installed in slot 1.
SLOT-1 CARD:	NONE	No card installed in slot 1, or slot 1 is not assigned.
SLOT-1 CARD:	7YYY***	Non-701X series model number assigned to slot 1 by the user. The card may or may not be installed in the slot. Also, a different non-701X series card may be installed.
SLOT-1 CARD:	9990	Slot 1 assigned by user to simulate a 40-channel multiplexer. A non-701X card may be installed.
SLOT-1 CARD:	9991	Slot 1 assigned by user to simulate a 4 × 10 matrix. A non-701X card may be installed.
SLOT-2 CARD:	701X**	701X series card installed in slot 2.
SLOT-2 CARD:	NONE	No card installed in slot 2, or an unassigned card installed.
SLOT-2 CARD:	7YYY***	Non-701X series model number assigned to slot 2 by the user. The card may or may not be installed in the slot. Also, a different non-701X series card may be installed.
SLOT-2 CARD:	9990	Slot 2 assigned by user to simulate a quad 1 × 10 multiplexer. A non-701X card may be installed.
SLOT-2 CARD:	9991	Slot 2 assigned by user to simulate a 4 × 10 matrix. A non-701X card may be installed.

* Assumes that power is cycled whenever a card is installed or removed from the mainframe.
** Model 701X series card, such as the Model 7011, 7012 or 7013.
*** Models 7052 though 7402.

Perform the following steps to assign card TYPE.

1. Display the CARD CONFIG MENU (see paragraph 4.7, General rule #1).
2. Place the cursor on TYPE and press ENTER. The following message will be displayed:

```
SET CARD TYPE
SLOT-1   SLOT-2
```

SLOT-1 — To assign slot 1, place the cursor on SLOT-1 and press ENTER. A message indicating the current slot assignment will be displayed. For example, if slot 1 was last assigned as a Model 7052, the following message will be displayed:

```
SLOT-1 CARD: 7052
```

Note: If slot 1 is assigned as a Model 701X series card, you will not be able to change the assignment since that is the card that is actually installed in the slot. Press EXIT to return to the SET CARD TYPE menu.

1. Determine the correct assignment for slot 1 using the following guidelines:
   A. If slot 1 is empty and is not going to be used, assign it as "NONE". This will turn off the front panel channel status display for slot 1 since it is not going to be used.
   B. If using a non-701X series card (Models 7052 through 7402) that is installed in slot 1, assign slot 1 as that model number. For example, if the Model 7062 is installed in slot 1, assign slot 1 as "7062"
   C. If slot 1 is going to be used to simulate a 40 channel mux, assign it as "9990". To simulate a 4 × 10 matrix, assign it as "9991". Note that a non-701X series card left installed will be controlled while using slot 1 as a simulator.
2. Use the cursor keys (◁ and ▷) to display the correct slot assignment. In general, the ◁ cursor key increments the displayed model number while the ▷ cursor key decrements the model number.

3. With the correct slot assignment displayed, press ENTER. The display will return to the SET CARD TYPE menu.

SLOT-2 — To assign slot 2, place the cursor on SLOT-2 and press ENTER. A message indicating the current slot assignment will be displayed. For example, if slot 2 was last assigned as a Model 7052, the following message will be displayed:

SLOT-2 CARD: 7052

Note: If slot 2 is assigned as a Model 701X series card, you will not be able to change the assignment since that is the card that is actually installed in the slot. Press EXIT to return to the SET CARD TYPE menu.

1. Determine the correct assignment for slot 2 using the following guidelines:
   A. If slot 2 is empty and is not going to be used, assign it as "NONE". This will turn off the front panel channel status display for slot 1 since it is not going to be used.
   B. If using a non-701X series card (Models 7052 through 7402) that is installed in slot 2, assign slot 2 as that model number. For example, if the Model 7062 is installed in slot 2, assign slot 2 as "7062".
   C. If slot 2 is going to be used to simulate a 40 channel mux, assign it as "9990". To simulate a 4 × 10 matrix, assign it as "9991". Note that a non-701X series card left installed will be controlled while using slot 2 as a simulator.
2. Use the cursor keys (◁ and ▷) to display the correct slot assignment. In general, the ◁ cursor key increments the displayed model number while the ▷ cursor key decrements the model number.
3. With the correct slot assignment displayed, press ENTER. The display will return to the SET CARD TYPE menu.

4.7.2 #-OF-POLES

The pole configuration of some switching cards can be altered. For example, the Model 7011 is normally used as 2-pole, 40-channel multiplexer card. However, since Banks A and B can be isolated from Banks C and D, you can configure the card for 4-pole operation. In the 4-pole mode, channels are paired together to form 20 4-pole channels. See the Model 7011 Instruction Manual for details.

Switch cards that have an additional pole mode capability are summarized as follows:

	Pole Mode		
Card	1-Pole	2-Pole	4-Pole
7011	N/A	40 channels	20 channels
7056	20 channels	10 channels	N/A
7156	20 channels	10 channels	N/A

If you attempt to select an invalid pole mode, a settings conflict error will occur and the entry will be ignored.

Changing the pole mode for a slot could cause channels to become unavailable. As can be seen from the above table for the Model 7011 mux card, 20 channels become unavailable when changing from 2-pole to 4-pole operation. If one or more of those unavailable channels were included in the Scan List and/or in a Channel Pattern, then the entire Scan List and/or the affected Channel Pattern will be lost (cleared). See paragraph 4.5.2 and 4.5.5 for details.

Perform the following steps to display the #-OF-POLES menu:

1. Display the CARD CONFIG MENU (see paragraph 4.7, General rule #1).
2. Place the cursor on #-OF-POLES and press ENTER to access the following menu:

SELECT # OF POLES
SLOT-1 SLOT-2

SLOT-1 — Use this menu item to configure the pole mode for the card in slot 1. Place the cursor on SLOT-1 and press ENTER. The pole mode selections will be displayed. The cursor (flashing menu item) indicates the currently selected pole mode.

# OF POLES SLOT-1
1-POLE 2-POLE 4-POLE

1. To retain the displayed pole mode, press ENTER or EXIT. The instrument will return to the SELECT # OF POLES menu.
2. To change the displayed pole mode, place the cursor on the desired selection and press ENTER. The instrument will return to the SELECT # OF POLES menu.

SLOT-2 — Use this menu item to configure the pole mode for the card in slot 2. Place the cursor on SLOT-2 and press ENTER. The pole mode selections will be displayed. The cursor (flashing menu item) indicates the currently selected pole mode.

```
# OF POLES SLOT-2
1-POLE  2-POLE  4-POLE
```

1. To retain the displayed pole mode, press ENTER or EXIT. The instrument will return to the SELECT # OF POLES menu.
2. To change the displayed pole mode, place the cursor on the desired selection and press ENTER. The instrument will return to the SELECT # OF POLES menu.

4.7.3 CARD-PAIR

The CARD-PAIR is used to enable (on) or disable (off) the CARD-PAIR feature of the Model 7001. CARD-PAIR can be enabled to pair two similar type switching cards that have the same number of channels. When enabled, corresponding channels of both cards operate together as a pair. For example, closing Channel 4 of slot 1 will also close Channel 4 of slot 2. Conversely, closing Channel 5 of slot 2 will also close Channel 5 of slot 1. This feature is especially useful when performing four-wire scanning.

If enabling Card Pair adds a restricted channel to the Scan List and/or a Channel Pattern, then the entire Scan List and/or Channel Pattern is cleared. See paragraphs 4.5.2 and 4.5.5 for more information.

Perform the following steps to check or change the state of the CARD-PAIR feature:

1. Display the CARD CONFIG MENU (see paragraph 4.7, General rule #1).
2. Place the cursor on CARD-PAIR and press ENTER. The current state of the CARD-PAIR feature will be indicated by the flashing cursor:

```
SET CARD PAIR
OFF  ON
```

3. To retain the displayed CARD-PAIR state, press ENTER or EXIT. The instrument will return to the CARD CONFIG MENU.
4. To select the alternate state, place the cursor on the selection and press ENTER. The instrument will return to the CARD CONFIG MENU.

4.7.4 DELAY

The DELAY feature sets a channel delay for each of the two cards installed in the mainframe. The delay can be set from 00000.001 seconds (1msec) to 99999.999 seconds. This delay is in addition to the internally set relay settling time delay.

This user programmed delay is the time delay between channels during a scan. The first delay period occurs after the first channel(s) closes. In other words, the programmed delay does not occur at the beginning of a scan.

Perform the following steps to set the delay:

1. Display the CARD CONFIG MENU (see paragraph 4.7, General rule #1).
2. Place the cursor on DELAY and press ENTER. The following message will be displayed:

```
SET DELAY FOR:
SLOT-1  SLOT-2
```

SLOT-1 — To set the delay for the card in slot 1, place the cursor on SLOT-1 and press ENTER. The currently set delay will be displayed. For example, if the card in slot 1 is set for a one second delay, the following message will be displayed:

```
(1) DELAY = 00001.000
```

1. To change the delay period, use the cursor keys and the keypad to key in the desired value.
2. With the desired delay displayed, press ENTER. The instrument will return to the SET DELAY FOR: menu.

SLOT-2 — To set the delay for the card in slot 2, place the cursor on SLOT-2 and press ENTER. The currently set delay will be displayed. For example, if the card in slot 2 is set for a 10 second delay, the following message will be displayed:

```
(2) DELAY = 00010.000
```

1. To change the delay period, use the cursor keys and the keypad to key in the desired value.
2. With the desired delay displayed, press ENTER. The instrument will return to the SET DELAY FOR: menu.

4.7.5 READ-I/O-CARD

This menu selection is used to identify if there are any I/O cards installed in the Model 7001.

1. Display the CARD CONFIG MENU (see paragraph 4.7, General Rule #1).
2. Place the cursor on READ-I/O-CARD and press ENTER to display the model number of the I/O card. If no I/O card is installed, the following message will be displayed:

   ```
   No I/O Cards
   ```

3. Press EXIT to return to the CARD CONFIG MENU.

4.8 SCAN CONFIG

Various operations to configure a scan are performed from the CONFIGURE SCAN menu. The menu structure is shown and summarized in Table 4-6 (cont.).

Table 4-6
CONFIGURE SCAN menu structure

Menu item	Description
CHAN-CONTROL	Configure Channel Layer:
CHANNEL-SPACING	Select channel spacing:
TIMER	Use a timer to select each channel in the scan.
EXTERNAL	Use an external trigger to select each channel.
GPIB	Use a bus trigger to select each channel.
MANUAL	Use STEP key to select each channel.
TRIGLINK	Use a Trigger Link trigger to select each channel.
ASYNCHRONOUS	Use separate lines for In/Out triggers.
SEMI-SYNCHRONOUS	Use same line for In/Out triggers.
IMMEDIATE	Use to scan channels immediately.
HOLD	Use to hold up the scan in the channel layer.
NUMBER-OF-CHANS	Define number of channels to scan:
USE-SCANLIST-LENGTH	Count = number of channel entries in scan list.
CHAN-COUNT	User defined count:
INFINITE	Repeat channel scanning indefinitely.
ENTER-CHAN-COUNT	Count = user defined value (1 to 9999)
CONTROL	Select trigger control mode:
SOURCE	Enable the Source Bypass.

Table 4-6 (cont.)
CONFIGURE SCAN menu structure

Menu item	Description
SCAN-CONTROL	Configure Scan Layer:
SCAN-SPACING	Select scan spacing:
TIMER	Use the timer to control scan spacing.
EXTERNAL	Use external triggers to control scan spacing.
GPIB	Use bus triggers to control scan spacing.
MANUAL	Use STEP key to control scan spacing.
TRIGLINK	Use Trigger Link triggers to control scan spacing.
IMMEDIATE	Use to pass operation immediately into the channel layer.
HOLD	Use to hold up the scan in the scan layer.
NUMBER-OF-SCANS	Define number of scans to be performed:
INFINITE	Repeat scan indefinitely.
ENTER-SCAN-COUNT	Count = user defined value (1 to 9999).
CONTROL	Select trigger control mode:
SOURCE	Enable Source Bypass.
ACCEPTOR	Disable Source Bypass.
ARM-CONTROL	Configure Arm Layer:
ARM SPACING	Select arm spacing control:
MANUAL	Use STEP key to arm scanner.
IMMEDIATE	Use to arm scanner immediately.
GPIB	Use a bus trigger to arm scanner.
EXTERNAL	Use an external trigger to arm scanner.
TRIGLINK	Use a Trigger Link trigger to arm scanner.
HOLD	Use to hold up the scan in the arm layer.
ARM-COUNT	Define number of times to arm scanner:
INFINITE	Continuously re-arm scanner.
ENTER-ARM-COUNT	User defined count value (1 to 9999).
TRIGGER-CONTROL	Select trigger control mode:
SOURCE	Enable Source Bypass.
ACCEPTOR	Disable Source Bypass.
CHAN-RESTRICTIONS	Define channel restrictions:
SINGLE-CHAN	Enable/disable Single Channel Mode
RESTRICTED-CHANNELS	Designate channels that cannot be closed.

General rules to use CONFIGURE SCAN:

1. The CONFIGURE SCAN menu is displayed by placing the instrument in the channel status display state, and then pressing the SCAN CONFIGURATION key. If already in the menu structure, the CONFIGURE SCAN menu can be displayed by pressing and releasing the EXIT key until the CONFIGURE SCAN menu selections are displayed (see next rule). The CONFIGURE SCAN menu selections are shown as follows:

```
CONFIGURE SCAN
CHAN-CONTROL   SCAN-CONTROL ▶
◀ ARM-CONTROL   CHAN-RESTRICTIONS
```

2. The EXIT key causes the display to back up to the previous menu level. Also, keyed-in parameter

changes are ignored if an EXIT is performed. When the CONFIGURE SCAN menu is displayed, pressing EXIT will disable SCAN CONFIGURATION.

3. The position of the cursor is denoted by the blinking menu selection or parameter. The cursor is moved from one item to the next using the cursor keys (◁ and ▷).
4. A displayed arrow (◀ or ▶) indicates that there is more information or additional menu items to select from. When "▶ " is displayed, use the ▷ cursor key to display the additional message(s), and conversely, when "◀ " is displayed, use the ◁ cursor key.
5. A numeric parameter is keyed in by placing the cursor on the digit to be changed, and pressing the appropriate key on the keypad. After keying in a number, the cursor will move to the next digit to the right.
6. A parameter change is only executed when the ENTER key is pressed.
7. ENTERing an invalid parameter generates an error and ignores the entry.
8. The INFO key can be used anywhere in the menu structure to display helpful information messages concerning operation. To cancel an information message, press EXIT or INFO a second time.

4.8.1 CHAN-CONTROL

Channel control is used for the following operations:

- To select the event that controls the time period (CHANNEL SPACING) between channel closures of a scan.
- Designate the NUMBER OF CHANS (channels) in the scan.
- Enable or disable the Source Bypass.

Perform the following steps to display the CHANNEL CONTROL menu:

1. Display the CONFIGURE SCAN menu (see paragraph 4.8, General rule #1).
2. Use the cursor keys (◁ and ▷) to place the cursor on CHAN-CONTROL and press ENTER to access the following menu:

```
CHANNEL CONTROL
CHANNEL-SPACING        NUMBER-OF-CHANS ▶
◀ CONTROL
```

CHANNEL SPACING — Use this menu item to select the event that controls the time period between channel closures of the scan. With the CHANNEL CONTROL menu displayed, select this menu item by placing the cursor on CHANNEL-SPACING and pressing ENTER. The following menu will be displayed:

```
SELECT CHAN SPACING
TIMER  EXTERNAL  GPIB  MANUAL ▶
◀ TRIGLINK  IMMEDIATE  HOLD
```

Timer — Use the timer to control channel spacing. The timer is used to set a time interval between channel closures of the scan. The timer can be set for an interval from zero to 99999.999 seconds with 0.001 second (1msec) resolution. The first interval begins after the first channel of the scan closes. Perform the following steps to use the timer:

1. With the SELECT CHAN SPACING menu displayed, place the cursor on TIMER and press ENTER. A message indicating the currently set time interval (in seconds) will be displayed. If, for example the timer is set to 1msec, the following message will be displayed:

   ```
   INTERVAL = 00000.001
   ```

2. To retain the displayed timer interval, press EXIT or ENTER. The instrument will return to the CHANNEL CONTROL menu.
3. To set a different time interval, use the keypad to key in the value (in seconds) and press ENTER. The instrument will return to the CHANNEL CONTROL menu.

Note: The front panel STEP key (see MANUAL) is active with the timer selected. Each press of the STEP key will select the next channel of the scan. This can be used to quickly step through a scan that has a relatively long timer interval.

External — With this selection, external triggers are used to control channel spacing for the scan. Each trigger stimulus applied to the Model 7001 will open the current channel and close the next channel of the scan. The external trigger is applied to the rear panel "EXTERNAL TRIGGER" BNC connector. In the external trigger mode, the Model 7001 can be used to trigger another instrument. After a channel is closed and settled, a trigger pulse is applied to the rear panel "CHANNEL READY" BNC connector. This trigger pulse can, for example, be used to trigger a DMM to take a reading. External triggering is covered in detail in paragraph 4.10.

Select external triggering from the SELECT CHAN SPACING menu by placing the cursor on EXTERNAL and pressing ENTER. The instrument will return to the CHANNEL CONTROL menu.

Note: The front panel STEP key (see MANUAL) is active with external triggering selected. Each press of the STEP key will select the next channel of the scan.

GPIB—With this selection, bus triggers are used to control channel spacing for the scan. Each trigger sent over the bus (GET or *TRG) will open the current channel and close the next channel of the scan. See Section 5 for detailed information on bus triggers.

Select bus triggering from the SELECT CHAN SPACING menu by placing the cursor on GPIB and pressing ENTER. The instrument will return to the CHANNEL CONTROL menu.

Note: The front panel STEP key (see MANUAL) is active with bus triggering selected. Each press of the STEP key will select the next channel of the scan.

Manual—With this selection, the front panel STEP key is used to control channel spacing. Each time the STEP key is pressed, the current channel of the scan will open and the next channel will close.

Select manual triggering from the CHANNEL SPACING menu by placing the cursor on MANUAL and pressing ENTER. The instrument will return to the CHANNEL CONTROL menu.

Note: The front panel STEP key is active when TIMER, EXTERNAL, GPIB or TRIGGER LINK is selected.

Triglink — With this selection, channel spacing of the scan is controlled by the Trigger Link of the Model 7001. Trigger Link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Each trigger stimulus applied to the Model 7001 will open the current channel and close the next channel of the scan. See paragraph 4.11 for details on using the Trigger Link.

Note: The front panel STEP key (see MANUAL) is active with Trigger Link selected. Each press of the STEP key will select the next channel of the scan.

Select the Trigger Link from the SELECT CHAN SPACING menu by placing the cursor on TRIGLINK and pressing ENTER. The following menu will be displayed:

```
SET TRIGGERLINK MODE
ASYNCHRONOUS   SEMI-SYNCHRONOUS
```

ASYNCHRONOUS — The asynchronous trigger link mode is used for trigger configurations that require input and output triggers to be routed on separate lines. Perform the following steps to select the asynchronous mode, and to select the input and output trigger lines for the Model 7001:

1. With the SET TRIGGERLINK MODE menu displayed, place the cursor on ASYNCHRONOUS and press ENTER. The following message will be displayed:

   ```
   SELECT INPUT LINE
   #1 #2 #3 #4 #5 #6
   ```

   The position of the cursor indicates the currently selected input line.

2. To select a trigger input line for the Model 7001, place the cursor on the desired line number and press ENTER. The following message will be displayed:

   ```
   SELECT OUTPUT LINE
   #1 #2 #3 #4 #5 #6
   ```

   The position of the cursor indicates the currently selected output line.

3. To select a trigger output line for the Model 7001, place the cursor on a different line number and press ENTER. The instrument will return to the SET TRIGGERLINK MODE menu. Note that you cannot use the same trigger line for both input and output.

SEMI-SYNCHRONOUS—In this mode, the input and output triggers for the Model 7001 are assigned to the same line. Perform the following steps to select the semi-synchronous mode, and to select the trigger line:

1. With the SET TRIGGERLINK MODE menu displayed, place the cursor on SEMI-SYNCHRONOUS and press ENTER. The following message will be displayed:

   SET SEMI-SYNC LINE
   #1 #2 #3 #4 #5 #6

   The position of the cursor indicates the currently selected trigger line.

2. To select a trigger line for the Model 7001, place the cursor on the desired line number and press ENTER. The instrument will return to the SET TRIGGERLINK MODE menu.

Immediate — With this selection, events (such as the TIMER and EXTERNAL triggers) do not control channel spacing. Once the scan starts, the Model 7001 will step through it as fast as the internal settling time and user programmed delay (see paragraph 4.7) will allow.

Select immediate triggering from the SELECT CHAN SPACING menu by placing the cursor on IMMEDIATE and pressing ENTER. The instrument will return to the CHANNEL CONTROL menu.

Hold — When HOLD is selected, channel spacing is suppressed. As a result the, scan is stopped and will not continue until HOLD is cancelled by selecting another channel spacing selection. Select trigger hold from the SET CHAN SPACING menu by placing the cursor on HOLD and pressing ENTER. The instrument will return to the CHANNEL CONTROL menu.

NUMBER OF CHANS — Use this menu item to define the number of channels to be scanned. With the CHANNEL CONTROL menu displayed, select this menu item by placing the cursor on NUMBER-OF-CHANS and pressing ENTER. The following menu will be displayed:

NUMBER OF CHANNELS
USE-SCANLIST-LENGTH CHAN-COUNT

Use-scanlist-length — With this selection, the number of channels in the scan will be determined by the number of channels defined in the scan list. For example, if the scan list is made up of channels 1!1, 1!2, 1!3 and 1!4, the number of channels to be scanned will be four. Select scan list length count from the NUMBER OF CHANNELS menu by placing the cursor on USE-SCANLIST-LENGTH and pressing ENTER. The display will return to the CHANNEL CONTROL menu.

Chan-count — With this selection, the user determines the number (count) of channels to scan. The user programmed count can be smaller, equal to, or larger than the number of channels in the scan list. For example, if the scan list is made up of four channels (1!1, 1!2, 1!3 and 1!4), the user can program a count of 12. With this count value, the instrument will repeat the channel scan three times. An advantage of repeating channels (rather than scans) is that delays in the scan layer of operation (SCAN CONTROL) are avoided. The channel spacing delay between all 12 channels are the same.

Select CHAN-COUNT from the NUMBER OF CHANNELS menu by placing the cursor on CHAN-COUNT and pressing ENTER. The following menu will be displayed:

CHANNEL COUNT
INFINITE ENTER-CHAN-COUNT

INFINITE — Use this selection to continuously repeat the scan. With the CHANNEL COUNT menu displayed, select this menu item by placing the cursor on INFINITE and pressing ENTER. The display will return to the CHANNEL CONTROL menu.

ENTER-CHAN-COUNT — Use this selection to define the number of channels in the scan. Perform the following steps to define a finite count:

1. With the CHANNEL COUNT menu displayed, place the cursor on ENTER-CHAN-COUNT and press ENTER. A message indicating the current count will be displayed.

   CHANNEL COUNT = 0010

   The above message indicates that the current count is set to 10.

2. To program for a different count (1 to 9999), use the keypad to enter the count value.
3. With the desired count value displayed, press ENTER. The display will return to the CHANNEL CONTROL menu.

CONTROL — Use this menu item to enable or disable the source bypass. The source bypass is used to bypass the channel spacing event on the first pass through the scan. With the CHANNEL CONTROL menu displayed, select this menu item by placing the cursor on CONTROL and pressing ENTER. The following menu will be displayed:

```
TRIGGER CONTROL
SOURCE   ACCEPTOR
```

Source — With this selection, the source bypass is enabled. The channel spacing event will be bypassed on the first pass through the channel layer if EXTERNAL or TRIG LINK channel spacing is selected. This will allow the first channel in the scan to close without having to wait for the programmed event.

Acceptor — With this selection, the source bypass is disabled.

4.8.2 SCAN CONTROL

Scan control is used for the following operations:

- To select the event that controls scan spacing.
- Designate the NUMBER-OF-SCANS to be performed.
- Enable or disable the Source Bypass.

Perform the following steps to display the SCAN CONTROL menu:

1. Display the CONFIGURE SCAN menu (see paragraph 4.8, General rule #1).
2. Use the cursor keys (◁ and ▷) to place the cursor on SCAN-CONTROL and press ENTER to access the following menu:

```
SCAN CONTROL
SCAN-SPACING   NUMBER-OF-SCANS ▶
◀ CONTROL
```

SCAN-SPACING — Use this menu item to select the event that controls the time period between scans. With the SCAN CONTROL menu displayed, select this menu item by placing the cursor on SCAN-SPACING and press ENTER. The following menu will be displayed:

```
SELECT SCAN SPACING
TIMER   EXTERNAL   GPIB   MANUAL ▶
◀ TRIGLINK   IMMEDIATE   HOLD
```

Timer — Use the timer feature to control scan spacing. The timer is used to set a time interval between scans. The timer can be set for an interval from zero to 99999.999 seconds with 0.001 second (1msec) resolution. After a scan is triggered to start, the next scan will start at the end of the programmed timer interval. If however, the programmed timer interval is shorter than the time it takes to complete a single scan, the next scan will not start until the previous scan is completed.

Note: The front panel STEP key (see MANUAL) is active with the timer selected. Pressing the STEP key after the completion of a scan will start the next scan (assuming the Model 7001 is programmed for another scan; see NUMBER OF SCANS).

Perform the following steps to use the timer:

1. With the SELECT SCAN SPACING menu displayed, place the cursor on TIMER and press ENTER. A message indicating the currently set time interval (in seconds) will be displayed:

   ```
   INTERVAL = 00000.001
   ```

2. To retain the displayed timer interval, press EXIT or ENTER. The instrument will return to the SELECT SCAN CONTROL menu.
3. To set a different time interval, use the keypad to key in the value (in seconds) and press ENTER. The instrument will return to the SCAN CONTROL menu.

External — With this selection, external triggers are used to control scan spacing. A trigger stimulus applied to the Model 7001 will pass operation into the channel layer. The external trigger is applied to the rear panel "EXTERNAL TRIGGER" BNC connector. See paragraph 4.10 for detailed information on external triggering.

Note: The front panel STEP key (see MANUAL) is active with external triggering selected. Pressing the STEP key after the completion of a scan will start the next scan (assuming the Model 7001 is programmed for another scan; see NUMBER OF SCANS).

Select external triggering from the SELECT SCAN SPACING menu by placing the cursor on EXTERNAL and pressing ENTER. The display will return to the SCAN CONTROL menu.

GPIB — With this selection, bus triggers are used to control scan spacing. Operation will pass into the channel layer when a bus trigger (GET or *TRG) is received by the Model 7001. See Section 5 for detailed information on bus triggers.

Note: The front panel STEP key (see MANUAL) is active with bus triggering selected. Pressing the STEP key after the completion of a scan will start the next scan (assuming the Model 7001 is programmed for another scan; see NUMBER OF SCANS).

Select bus triggering from the SELECT SCAN SPACING menu by placing the cursor on GPIB and pressing ENTER. The display will return to the SCAN CONTROL menu.

Manual — With this selection, the front panel STEP key is used to control scan spacing. Operation will pass into the channel layer when STEP is pressed.

Note: The front panel STEP key is active when TIMER, EXTERNAL, GPIB or TRIGGER LINK is selected.

Select manual triggering from the SELECT SCAN SPACING menu by placing the cursor on MANUAL and pressing ENTER. The instrument will return to the SCAN CONTROL menu.

Triglink — With this selection, scan spacing is controlled by the Trigger Link of the Model 7001. Trigger Link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Operation passes into the channel layer when the Model 7001 receives a trigger over the Trigger Link. See paragraph 4.11 for details on using the Trigger Link.

Note: The front panel STEP key (see MANUAL) is active with the Trigger Link selected. Pressing the STEP key after the completion of a scan will start the next scan (assuming the Model 7001 is programmed for another scan; see NUMBER OF SCANS).

Select the Trigger Link from the SELECT SCAN SPACING menu by placing the cursor on TRIGLINK and pressing ENTER. The following menu will be displayed:

```
SELECT INPUT LINE
#1   #2   #3   #4   #5   #6
```

The position of the cursor indicates the currently selected input line.

To select a trigger input line for the Model 7001, place the cursor on the desired line number and press ENTER. The following message will be displayed:

```
SELECT OUTPUT LINE
#1   #2   #3   #4   #5   #6
```

The position of the cursor indicates the currently selected output line.

To select a trigger output line for the Model 7001, place the cursor on a different line number and press ENTER. Note that you cannot use the same trigger line for both input and output.

Immediate — With IMMEDIATE selected, operation passes immediately into the channel layer. Select immediate scanning from the SELECT SCAN SPACING menu by placing the cursor on IMMEDIATE and pressing ENTER. The instrument will return to the SCAN CONTROL menu.

Hold — When HOLD is selected, scan spacing is suppressed. As a result, operation will not continue until HOLD is cancelled by selecting one of the other scan spacing selections. Select HOLD from the SELECT SCAN SPACING menu by placing the cursor on HOLD and pressing ENTER. The instrument will return to the SCAN CONTROL menu.

NUMBER-OF-SCANS — Use this menu item to define the number of scans to be performed by the Model 7001. With the SCAN CONTROL menu displayed, select this menu item by placing the cursor on NUMBER-OF-SCANS and press ENTER. The following menu will be displayed:

```
NUMBER OF SCANS
INFINITE   ENTER-SCAN-COUNT
```

Infinite — Use this selection to continuously repeat the scan. Select continuous scanning from the NUMBER OF SCANS menu by placing the cursor on INFINITE and pressing ENTER. The display will return to the SCAN CONTROL menu.

Enter-Scan-Count — With this selection, the user determines the number of scans to perform. You can program the Model 7001 to perform from 1 to 9999 scans. For example, if you enter a scan count of 10, the programmed scan will be performed 10 times. Perform the following steps to enter the scan count:

1. With the NUMBER OF SCANS menu displayed, place the cursor on ENTER-SCAN-COUNT and press ENTER. A message indicating the current scan count will be displayed.

   ```
   SCAN COUNT = 0001
   ```

   The above scan count indicates that the Model 7001 will perform one scan. A value of "0000" indicates that the scan count is set to infinite.

2. To program for a different count (1 to 9999), use the keypad to enter the count value.
3. With the desired count value displayed, press ENTER. The display will return to the SCAN CONTROL menu.

CONTROL —Use this menu item to enable or disable the source bypass. The source bypass is used to bypass the scan spacing event on the first pass through the scan. With the SCAN CONTORL menu displayed, select this menu item by placing the cursor on CONTROL and pressing ENTER. The following menu will be displayed:

```
TRIGGER CONTROL
SOURCE   ACCEPTOR
```

Source — With this selection, the source bypass is enabled. The scan spacing event will be bypassed on the first pass through the scan layer if EXTERNAL or TRIG LINK scan spacing is selected. This will allow operation to proceed on into the channel layer without having to wait for the programmed event.

Acceptor — With this selection, the source bypass is disabled.

4.8.3 ARM CONTROL

Arm control is used for the following operations:

- To select the arming event (ARM SPACING) for the scanner.
- Designate the number of times the scanner is to be armed (ARM COUNT)
- Enable or disable the Source Bypass.

Perform the following steps to display the ARM CONTROL menu:

1. Display the CONFIGURE SCAN menu (see paragraph 4.8, General rule #1).
2. Use the cursor keys (◁ and ▷) to place the cursor on ARM CONTROL and press ENTER to access the following menu:

   ```
   SETUP ARM CONTROL
   ARM-SPACING   ARM-COUNT ▶
   ◀ TRIGGER-CONTROL
   ```

ARM-SPACING — This menu item is used to select the event that controls the arm spacing. To select this menu item, place the cursor on ARM-SPACING and press ENTER. The following menu will be displayed:

```
ARM SPACING
MANUAL   IMMEDIATE   GPIB ▶
◀ EXTERNAL   TRIGLINK   HOLD
```

Manual — With this selection, the front panel STEP key is used to control arm spacing. Operation will pass into the scan layer when the STEP key is pressed.

Note: The front panel STEP key is active when TIMER, EXTERNAL, GPIB or TRIGGER LINK is selected.

To select manual triggering (STEP key) from the SELECT ARM SPACING menu, place the cursor on MANUAL and press ENTER. The instrument will return to the SETUP ARM CONTROL menu.

Immediate — With this selection, operation will pass immediately into the scan layer.

Select immediate triggering from the SELECT ARM SPACING menu by placing the cursor on IMMEDIATE and pressing ENTER. The instrument will return to the SETUP ARM CONTROL menu.

GPIB — With this selection, bus triggers are used to control arm spacing. Operation will pass immediately into the scan layer when a bus trigger (GET or *TRG) is received by the Model 7001. See Section 5 for detailed information on bus triggers.

Note: The front panel STEP key (see MANUAL) is active with bus triggering selected. Pressing the STEP key will pass operation into the scan layer.

To select bus triggering from the SELECT ARM SPACING menu, place the cursor on GPIB and press ENTER. The display will return to the SETUP ARM CONTROL menu.

External — With this selection, external triggers are used to control arm spacing. A trigger stimulus applied to the Model 7001 will pass operation into the scan layer. The external trigger is applied to the rear panel "EXTERNAL TRIGGER" BNC connector. See paragraph 4.10 for detailed information on external triggering.

Note: The front panel STEP key (see MANUAL) is active with external triggering selected. Pressing the STEP key will pass operation into the scan layer.

To select external triggering from the SELECT ARM SPACING menu, place the cursor on EXTERNAL and press ENTER. The instrument will return to the SETUP ARM CONTROL menu.

Triglink — With this selection, arm spacing is controlled by the Trigger Link of the Model 7001. Trigger Link is an enhanced trigger system that uses up to six lines to direct trigger pulses to and from other instruments. Operation passes into the scan layer when the Model 7001 receives a trigger over the Trigger Link. See paragraph 4.11 for details on using the Trigger Link.

Note: The front panel STEP key (see MANUAL) is active with the Trigger Link selected. Pressing the STEP key will pass operation into the scan layer.

To select the Trigger Link from the SELECT ARM SPACING menu, place the cursor on TRIGLINK and press ENTER. The following menu will be displayed:

```
SELECT INPUT LINE
#1  #2  #3  #4  #5  #6
```

The position of the cursor indicates the currently selected input line.

To select a trigger input line for the Model 7001, place the cursor on the desired line number and press ENTER. The following message will be displayed:

```
SELECT OUTPUT LINE
#1  #2  #3  #4  #5  #6
```

The position of the cursor indicates the currently selected output line.

To select a trigger output line for the Model 7001, place the cursor on a different line number and press ENTER. Note that you cannot use the same trigger line for both input and output.

Hold — When HOLD is selected, arm spacing is suppressed. As a result, operation will not pass into the scan layer until HOLD is cancelled by selecting one of the other arm spacing selections. Select HOLD from the SELECT ARM SPACING menu by placing the cursor on HOLD and pressing ENTER. The instrument will return to the SETUP ARM CONTROL menu.

ARM-COUNT — This menu item is used to define the number of times operation will return to the arm layer. With the SETUP ARM CONTROL menu displayed, select this menu item by placing the cursor on ARM-COUNT and press ENTER. The following menu will be displayed:

```
ARM COUNT
INFINITE   ENTER-ARM-COUNT
```

Infinite — Use this selection to continuously return operation to the arm layer. Select continuous arming from the ARM COUNT menu by placing the cursor on INFINITE and pressing ENTER. The display will return to the SETUP ARM CONTROL menu.

Enter-Arm-Count — With this selection, the user determines the number of times operation returns to the arm layer. You can program the Model 7001 to arm up to 9999 times. Perform the following steps to enter the arm count:

1. With the ARM COUNT menu displayed, place the cursor on ENTER-ARM-COUNT and press ENTER. A message indicating the current arm count will be displayed.

   ```
   ARM COUNT = 0001
   ```

The above arm count indicates that the scanner will arm one time. An arm count of "0000" indicates that infinite is selected.

2. To program for a different count (1 to 9999), use the keypad to enter the count value.
3. With the desired count value displayed, press ENTER. The display will return to the SETUP ARM CONTROL menu.

TRIGGER CONTROL — Use this menu item to enable or disable the source bypass. The source bypass is used to bypass the arm spacing event on the first pass through the scan. With the SETUP ARM CONTROL menu displayed, select this menu item by placing the cursor on TRIGGER-CONTROL and pressing ENTER. The following menu will be displayed:

```
TRIGGER CONTROL
SOURCE   ACCEPTOR
```

Source — With this selection, the source bypass is enabled. The arm spacing event will be bypassed on the first pass through the arm layer if EXTERNAL or TRIG LINK arm spacing is selected. This will allow operation to proceed on into the scan layer without having to wait for the programmed event.

Acceptor — With this selection, the source bypass is disabled.

4.8.4 Channel restrictions

The Model 7001 can be programmed for the following channel restrictions:

- The user can enable the SINGLE CHAN (channel) mode to prevent more than one channel from being closed at the same time.
- The user can define a list of RESTRICTED CHANNELS. Channels in this list cannot be closed.

Perform the following steps to display the CHANNEL RESTRICTIONS menu:

1. Display the CONFIGURE SCAN menu (see paragraph 4.8, General rule #1).
2. Use the cursor keys (◁ and ▷) to place the cursor on CHAN-RESTRICTIONS, and press ENTER to access the following menu:

```
CHANNEL RESTRICTIONS
SINGLE-CHAN   RESTRICTED-CHANNELS
```

SINGLE-CHAN — Use this menu item to enable or disable the single channel mode. With the single channel mode enabled (ON), only one channel can be closed. Two or more channels cannot be closed at the same time.

Perform the following steps to enable or disable the single channel mode:

1. With the CHANNEL RESTRICTIONS menu displayed, place the cursor on SINGLE-CHAN and press ENTER. The following message will be displayed:

```
SINGLE CHANNEL MODE
OFF   ON
```

Cursor position indicates the current status of the single channel mode.

2. Place the cursor on the desired state (ON or OFF) and press ENTER. The display will return to the CHANNEL RESTRICTIONS menu.

Operating Notes:

1. For Single Channel, when more than one channel is assigned to a channel list, only the lowest numbered channel in the lowest numbered slot will close when CLOSE is pressed. For example, assume the following channel list is defined:

```
SELECT CHANNELS 2!1, 2!2, 1!5
```

When CLOSE is pressed, Channel 1!5 will close.

2. When the single channel mode is enabled, all stored channel patterns are cleared. For example, if closed Channels 1!1 and 1!2 are stored at memory location #001 (M1), enabling single channel will clear that memory location.
3. The single channel mode cannot be enabled if two or more channels are currently closed.

RESTRICTED-CHANNELS — Used to designate channels that cannot be closed from either the front or over the bus. This is primarily used as a safety feature to prevent the inadvertent closing of a channel(s) that could cause damage to instrumentation or DUT (i.e. shorting a power supply in a matrix test system).

If you specify a channel to be restricted and it is already included in the Scan List and/or a Channel Pattern, a saved state error (+510) occurs and the entire Scan List and/or Channel pattern is cleared (lost)/ See paragraphs 4.5.2 and 4.5.5 for more information.

Perform the following steps to define the restricted channels:

1. With the CHANNEL RESTRICTIONS menu displayed, place the cursor on RESTRICTED-CHANNELS and press ENTER. The following message will be displayed:

   RESTRICTED CHANNELS
   SELECT CHANNELS

2. Use the keypad to enter the channel list and press EXIT.

4.9 Digital I/O port

The Model 7001's Digital I/O port is an 8-pin micro-DIN socket (J1007) located on the rear panel. Figure 4-9 shows a simplified schematic containing pin designations.

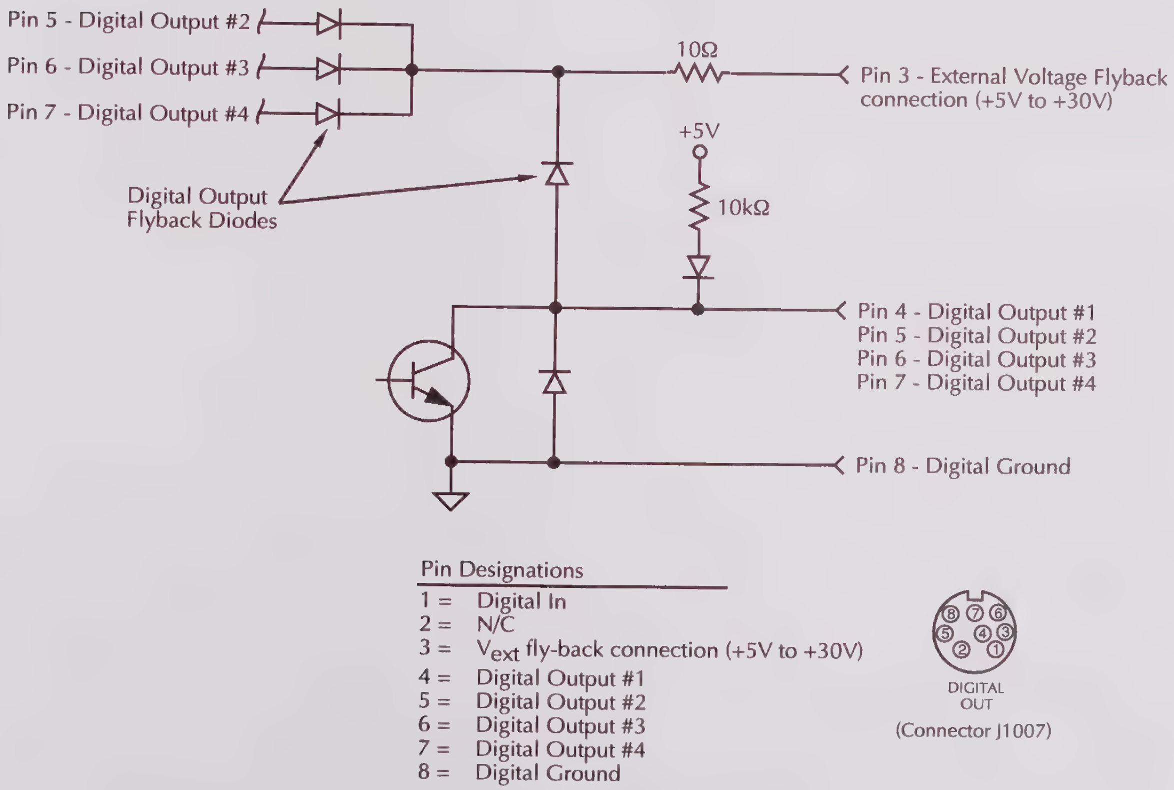

Pin 5 - Digital Output #2
Pin 6 - Digital Output #3
Pin 7 - Digital Output #4
10Ω
Pin 3 - External Voltage Flyback connection (+5V to +30V)
+5V
10kΩ
Digital Output Flyback Diodes
Pin 4 - Digital Output #1
Pin 5 - Digital Output #2
Pin 6 - Digital Output #3
Pin 7 - Digital Output #4
Pin 8 - Digital Ground
Pin Designations
1 = Digital In
2 = N/C
3 = Vext fly-back connection (+5V to +30V)
4 = Digital Output #1
5 = Digital Output #2
6 = Digital Output #3
7 = Digital Output #4
8 = Digital Ground
8
7
6
5
4
3
2
1
DIGITAL OUT
(Connector J1007)

Figure 4-9
Digital I/O port simplified schematic

The Model 7001's Digital I/O port can be used to control external circuitry. The port provides four output lines and one input line. Each open-collector output can be set high (+5V) or low (0V) and will sink up to 100mA. The four output lines can also operate external supplies from +5V to +30V.

Use the DIGITAL I/O MENU to select the following options (information about each menu item is contained in paragraph 4.6.3):

- OUTPUT-STATUS

  ON or OFF selectable for each output line (1 through 4). Use this option to check or change the output state. For example, the following OUTPUT-STATUS display is set to ON for digital output #1, while outputs #2 through #4 are set to OFF:

  ```
  DIGITAL OUTPUT LINES
  1=ON   2=OFF   3=OFF   4=OFF
  ```

  Changing the display to the following turns digital output #1, #3, #4 to OFF and output #2 to ON.

  ```
  DIGITAL OUTPUT LINES
  1=OFF   2=ON   3=OFF   4=OFF
  ```

- OUTPUT-POLARITY

  ACTIVE-HIGH or ACTIVE-LOW selectable for each output line (TTL1 through TTL4). Use to check or change the logic sense. Select the desired output line (TTL1 through TTL4), and check or change the output-polarity. For example, the following shows the display used to check or change TTL3 (digital output #3):

  ```
  SELECT OUTPUT LINE
  TTL1   TTL2   TTL3   TTL4
  ```

  Selecting TTL3 and pressing Enter changes the display to:

  ```
  TTL3 LOGIC SENSE
  ACTIVE-HIGH   ACTIVE-LOW
  ```

  ACTIVE-HIGH is the current setting for digital output #3.

- INPUT

  ON or OFF. Use this option to check or change the status of the digital input line. Sense is fixed at active-high (ON=5V).

4.9.1 Controlling digital circuitry

Each of the four digital, open-collector outputs (connector J1007, pins 4 through 7) includes a built-in pull up resistor to +5V. The output transistor is capable of sinking up to 100mA at voltages up to +30V.

Early versions of the Model 7001 have an additional 10kΩ resistor connected between the collector and the internal built-in test circuitry. Under certain combinations of output states, this resistor limits the output high to 2.5V. For example:

Output #1 set high (+5V)
Outputs #2, #3, and #4 set low (0V)
Actual output of digital output #1 is restricted to +2.5V

If using the digital output to sink current from external devices a Model 7001 containing the additional 10kΩ resistors will function correctly. The transistor switch is open restricting current flow through the external device in the high state (+5V). However, if the output is directly used as an input to a typical logic input, the 2.5V high state may not be reliably detected as a high. To correct this condition (if a 2.5V high is unacceptable), use one of the following solutions:

- Add external 1kΩ pull-up resistors to the logic circuit inputs.
- Remove the built-in test resistors (R606, R608, R610, and R612),
- Use an external voltage supply.

External voltage supply

Each output can be operated from external voltage supplies (voltage range from +5V to +30V applied through the device being driven). Refer to Figure 4-9 for a simplified schematic of the digital I/O port. The high current sink capacity of the output driver allows direct control of relays, solenoids, and lamps (no additional circuitry needed). Each output channel contains a fly-back diode for protection when switching inductive loads (such as a low power solenoid or relay coils). To use these fly-back diodes, connect the external supply voltage to pin 3 of J1007 (the digital I/O port). Make sure the external supply voltage is between +5V and +30V and the current required by the device does not exceed 100mA.

CAUTION

Do not apply more than 100mA maximum current or exceed +30V maximum voltage on pin 3 of J1007 (the digital I/O port). Applying current or voltage exceeding these limits may damage the instrument.

An externally powered relay connected to the digital output port is shown in Figure 4-10. Other externally powered devices can be similarly connected by replacing the relay with the device. When using the Model 7001's collector outputs to turn on externally powered devices, set the correspinding digital output line parameters as follows (set through the MAIN MENU > DIGITAL-I/O > OUTPUT-STATUS and OUTPUT-POLARITY menus):

OUTPUT-STATUS=ON
TTLX LOGIC-SENSE=ACTIVE-LOW

NOTE

The X in TTLX represents the digital output line number (TTL1 through TTL4). This parameter is set through the OUTPUT-POLARITY menu by selecting the desired digital output line number and pressing Enter.

In the low state (0V), the output transistor sinks current through the external device. In the high state, the output transistor is off (transistor switch is open). This interrupts current flow through the external device. Most applications use active-low (ON=0V) LOGIC-SENSE. Use the LOGIC-SENSE menu to check or change the sense of each digital output line (refer to OUTPUT-POLARITY in paragraph 4.6.3).

Outputs used as logic inputs

To use the digital outputs as logic inputs to active TTL, Low-power TTL, or CMOS inputs:

1. Connect the Model 7001 digital outputs to the logic inputs.
2. Connect the digital grounds.
3. Using the OUTPUT-STATUS menu, check the setting of the Model 7001 output lines. The OUTPUT-STATUS value for each output used should be ON.
4. Using the OUTPUT-POLARITY menu, check the logic-sense setting of the Model 7001 output lines (TTL1 through TTL4). Make sure the correct LOGIC-SENSE value is selected for each output line. The LOGIC-SENSE value varies according to the type of TTL, Low-power TTL, or CMOS inputs used (ACTIVE-HIGH or ACTIVE-LOW).

When low (0V), the output sink can drive at least 10 standard TTL inputs. When high (+5V), the 10kΩ pull-up resistor will source >100μA while remaining at >3.75V output (a reliable logic high).

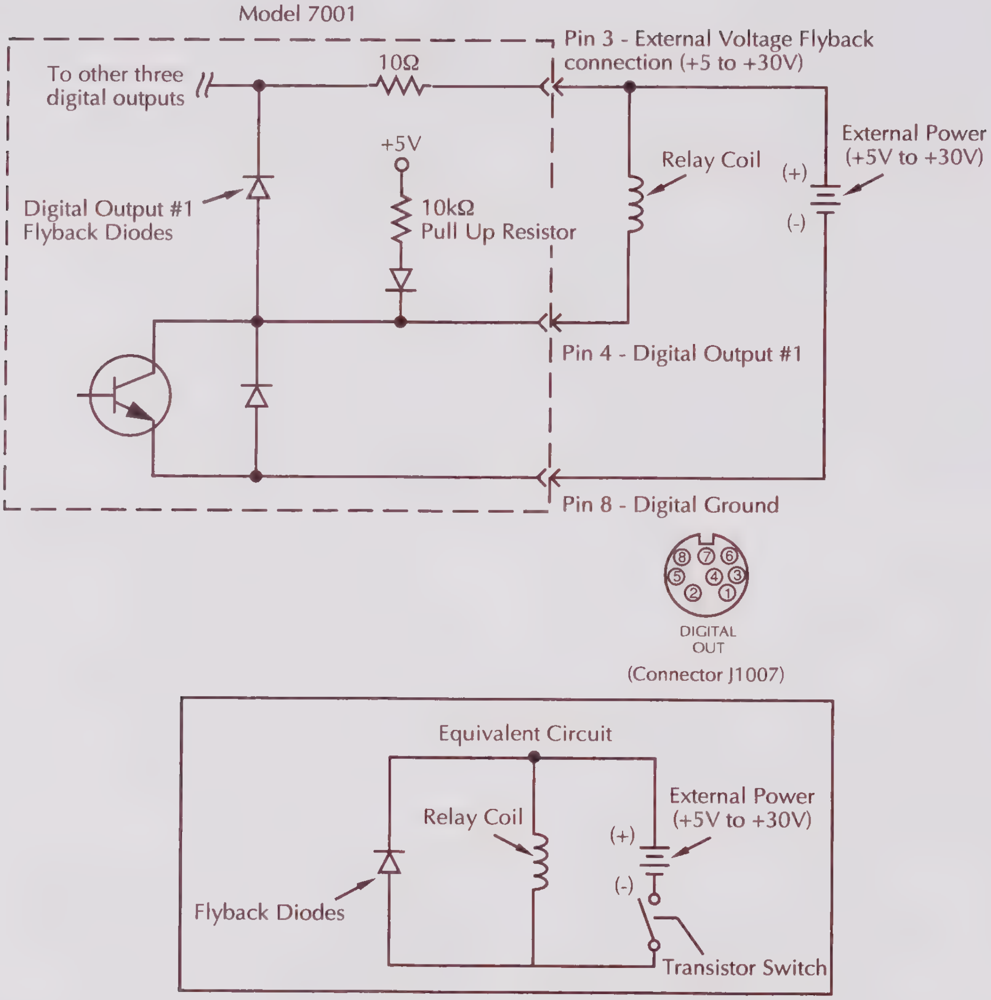

Model 7001
Pin 3 - External Voltage Flyback connection (+5 to +30V)
To other three digital outputs
10Ω
+5V
10kΩ Pull Up Resistor
Relay Coil
(+)
(-)
External Power (+5V to +30V)
Digital Output #1 Flyback Diodes
Pin 4 - Digital Output #1
Pin 8 - Digital Ground
8 7 6 5 4 3 2 1
DIGITAL OUT
(Connector J1007)
Equivalent Circuit
Relay Coil
(+)
(-)
External Power (+5V to +30V)
Flyback Diodes
Transistor Switch

Figure 4-10
Sample externally powered relay

4.9.2 Digital input channel

The Model 7001 has one digital input channel that is used to read a TTL input level. A TTL high on the input will be read as "ON".

The front panel MENU feature reads the level of the digital input channel.

4.9.3 I/O port connections

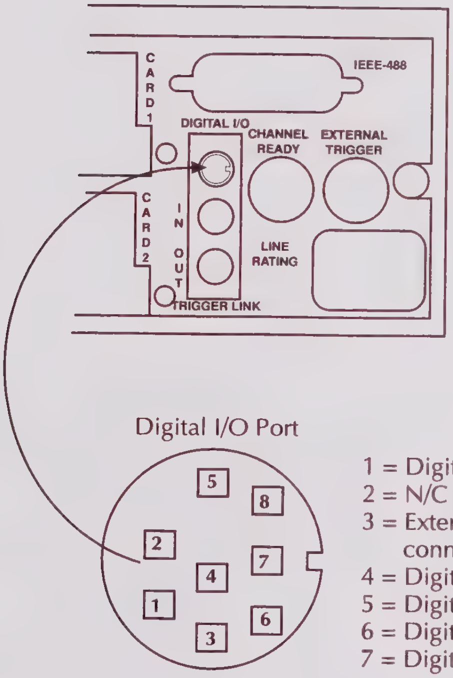
The DIGITAL I/O port is located on the rear panel as shown in Figure 4-11. This drawing also provides the pin identification for the 8-pin micro DIN female receptacle. Since the DIGITAL I/O receptacle is the same as the TRIGGER LINK receptacle, you can use a trigger link cable (Keithley Model 8501) to make connections.

By cutting a trigger link cable in two, it is possible to hard-wire the unterminated end directly to an external digital circuit.

By hard-wiring an external circuit to an 8-pin micro DIN female receptacle (see rear panel; Keithley Model 8501), you can use one complete Trigger Link cable for the digital I/O connections. Figure 4-12 provides pin identification for the Trigger Link cable when it is used for the DIGITAL I/O port.

CAUTION

Trigger Link and the Digital I/O port use the same type of connector. To prevent possible damage, do not connect the Digital I/O to the Trigger Link. Also, when connecting an external circuit to the Digital I/O, take care to not accidentally connect it to the Trigger Link.


CARD 1
IEEE-488
DIGITAL I/O
CHANNEL READY
EXTERNAL TRIGGER
CARD 2
IN
OUT
LINE RATING
TRIGGER LINK
Digital I/O Port
5
8
2
7
4
1
6
3

1 = Digital Input
2 = N/C
3 = External Voltage Flyback connection (up to 30V)
4 = Digital Output #1
5 = Digital Output #2
6 = Digital Output #3
7 = Digital Output #4

Figure 4-11
Digital I/O port

Common Commands
SCPI Command Subsystems
Servicing Information

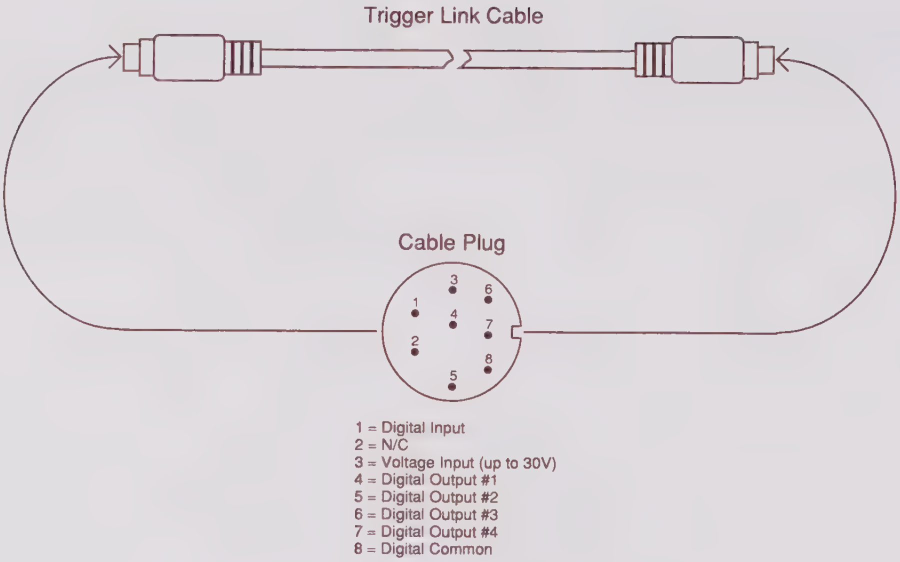

Trigger Link Cable
Cable Plug
1
2
3
4
5
6
7
8
1 = Digital Input
2 = N/C
3 = Voltage Input (up to 30V)
4 = Digital Output #1
5 = Digital Output #2
6 = Digital Output #3
7 = Digital Output #4
8 = Digital Common

Figure 4-12
Digital I/O connections using trigger link cable

4.10 External triggering

The Model 7001 has BNC connectors on the rear panel (see Figure 4-13) associated with external triggering. The EXTERNAL TRIGGER input jack allows the Model 7001 to be triggered by other instruments and the CHANNEL READY output jack allows the Model 7001 to trigger other instruments.

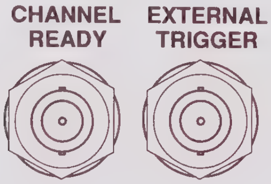

CHANNEL READY
EXTERNAL TRIGGER

Figure 4-13
External triggering connectors (BNC)

4.10.1 External trigger

The EXTERNAL TRIGGER input jack requires a falling-edge, TTL-compatible pulse with the specifications shown in Figure 4-14.

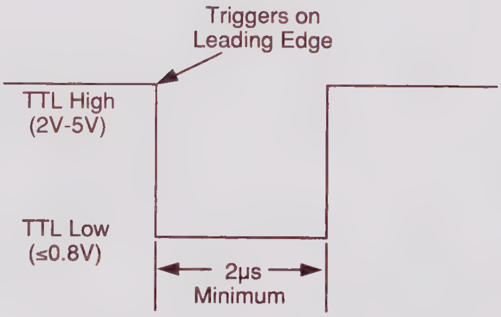

Triggers on Leading Edge
TTL High (2V-5V)
TTL Low (≤0.8V)
2µs Minimum

Figure 4-14
External trigger and asynchronous Trigger Link Input pulse specifications

In general, external triggers can be used as events to control scan operation. In order for the Model 7001 to respond to external triggers, the appropriate layers of scan operation must be configured for it. Paragraph 4.8 explains how to program the three layers of the scan.

4.10.2 Channel ready

The CHANNEL READY output jack provides a TTL-compatible output pulse that can be used to trigger other instrumentation. The specifications for this trigger pulse are shown in Figure 4-15.

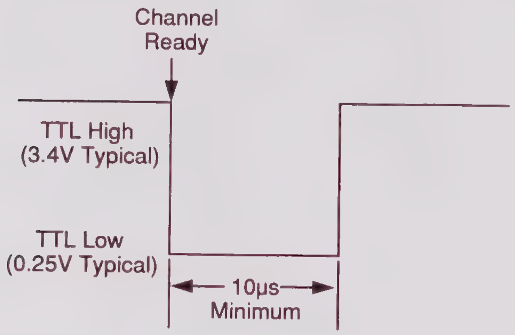


Figure 4-15
Channel ready and asynchronous Trigger Link Output pulse specifications

Typically, you would want the Model 7001 to output a trigger after each channel closes and settles (settling time includes the internally set relay settle time and the user programmed DELAY period; see paragraph 4.7). An output trigger will occur after each scanned channel as long as channel spacing is set to external. See paragraph 4.8.1 for details on programming the channel layer.

The Model 7001 can also output a trigger while in the scan and/or arm layers of operation. Figure 4-9 shows where these triggers occur in the trigger model. An output trigger will occur on each return path through the scan layer if the scan layer Source Bypass is enabled (Control = Source) and Scan Spacing is programmed for External. An output trigger will occur on each return path through the arm layer if the arm layer Source Bypass is enabled (Control = Source) and Arm Spacing is programmed for External. See paragraph 4.8.2 and 4.8.3 for programming the scan and arm layer.

4.10.3 External triggering example

In a typical test system, you may want to close a channel and then measure the DUT connected to that channel with a DMM such as the Keithley Model 196. Such a test system is shown in Figure 4-16 which uses a Model 7011 multiplexer card to switch 10 DUTs to the DMM.

The external trigger connections for this test system are shown in Figure 4-17. Channel Ready (output) of the Model 7001 is connected to External Trigger Input of the Model 196, and External Trigger (input) of the Model 7001 is connected to Voltmeter Complete Output of the Model 196.

For this test system, the Model 196 is configured for external triggering and the scan is configured as follows:

Scan List = 1!1-1!10,

Arm Layer:
  Arm Spacing = Immediate*
  Arm Count = 1*
  Arm Trigger Control = Acceptor*

Scan Layer:
  Scan Spacing = Immediate*
  Number of Scans = 1
  Scan Trigger Control = Acceptor*

Channel Layer:
  Channel Spacing = External
  Number of Channels = Use Scan list Length*
  Channel Trigger Control = Source*

* Indicates that the setting is the RESET (and factory) default condition.

Notice that Channel Trigger Control is set for Source. With this selection, scan operation will initially bypass the need for an external trigger to close the first channel. Since arm spacing and scan spacing are set for Immediate, the scan will start immediately as soon as the scanner is taken out of the idle state by pressing the STEP key.

When the front panel STEP key is pressed, the scanner will arm and close the first channel. After Channel 1!1 settles (channel ready), a trigger is sent from Channel

Ready of the Model 7001 to External Trigger Input of the Model 196 to trigger a measurement of DUT #1. After the Model 196 completes the measurement, it will output a trigger from Voltmeter Complete Output to External Trigger input of the Model 7001, which closes the next channel. After Channel 1!2 settles, a trigger is sent to the Model 196 to trigger a measurement of DUT #2. When the measurement is completed, a trigger is sent to the Model 7001 to close the next channel. After this channel settles, a trigger is sent to the DMM to trigger a measurement. This process continues until all 10 channels are scanned and measured. The data store of the Model 196 could be used to store the measurements as they occur.

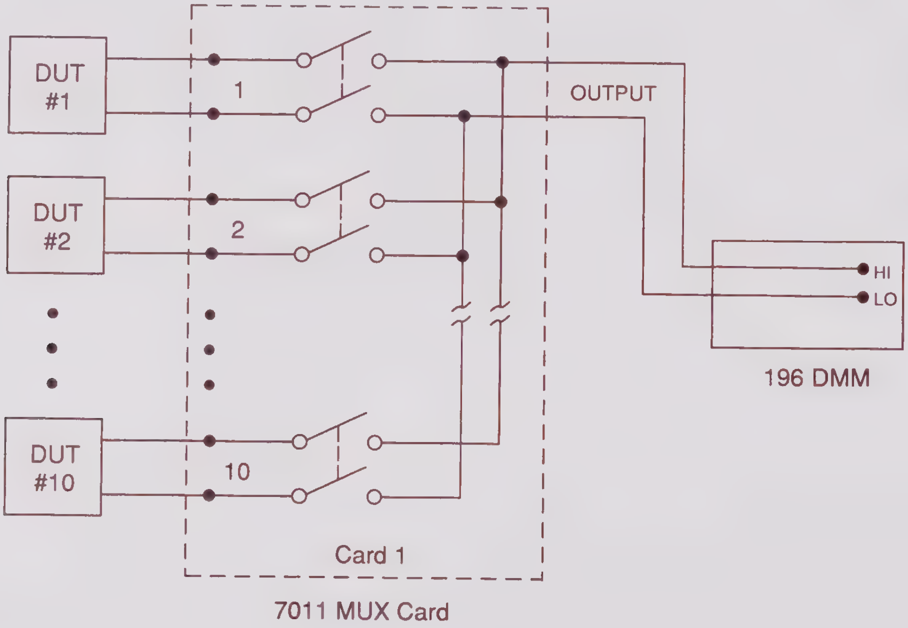

DUT #1
DUT #2
DUT #10
1
2
10
OUTPUT
HI
LO
196 DMM
Card 1
7011 MUX Card

Figure 4-16
DUT test system

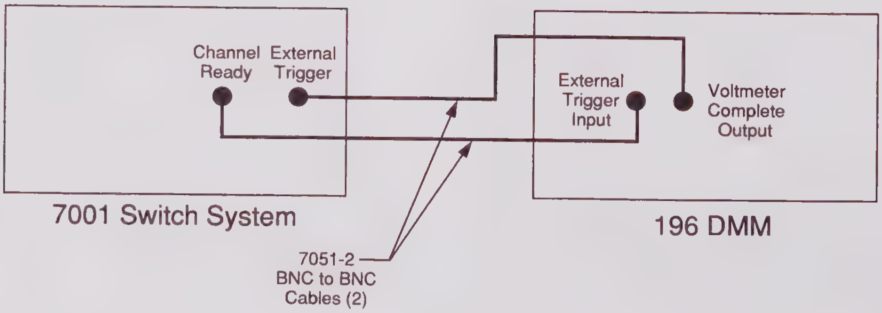

Channel Ready
External Trigger
7001 Switch System
External Trigger Input
Voltmeter Complete Output
196 DMM
7051-2 BNC to BNC Cables (2)

Figure 4-17
External trigger connectors

4.11 Trigger Link

The Model 7001 has enhanced external triggering capabilities using the Trigger Link. The Trigger Link has six lines allowing up to six instruments to be controlled over this trigger bus. The micro 8-pin DIN sockets used for the Trigger Link are shown in Figure 4-18.

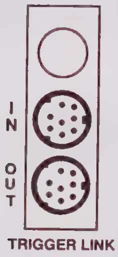


Figure 4-18
Trigger link connectors

NOTE

The two rear panel Trigger Link connectors are actually connected in parallel to each other. Thus, the IN and OUT labels are a misnomer. It does not matter which connector you use when connecting the Trigger Link to another instrument.

CAUTION

Trigger Link and the Digital I/O port use the same type of connector. To prevent possible damage, do not connect the Digital I/O to the Trigger Link. Also, when connecting an external circuit to the Digital I/O, take care to not accidentally connect it to the Trigger Link.

In general, Trigger Link input triggers to the Model 7001 are used to control scan operation. In order for the Model 7001 to respond to Trigger Link compatible triggers, the appropriate layers of the scan must be programmed for it. For example, if you want Trigger Link input triggers to control the channel scan process, you must program Channel Spacing for TRIGLINK trigger events. Typically, a Trigger Link output trigger from the Model 7001 would be used to trigger another instrument to measure the currently selected channel.

There are two modes of operation for Trigger Link; asynchronous and semi-synchronous. In the asynchronous mode, separate lines are used for input and output triggers, and in semi-synchronous mode, the same line is used for both input and output triggers.

4.11.1 Asynchronous operation

In the asynchronous operating mode, Trigger Link functions fundamentally in the same manner as External Triggering (see paragraph 4.10). Like External Triggering, the asynchronous mode uses separate lines for input and output triggers. Also, the asynchronous mode uses the same TTL-compatible pulses as External Triggering. The input trigger specifications for asynchronous mode are shown in Figure 4-14 and the output trigger specifications are shown in Figure 4-15.

For typical Asynchronous Trigger Link operation, the channel layer of the scan is configured with Channel Spacing set to TRIGLINK and Triggerlink Mode set to Asynchronous. You must also select input and output lines for the channel layer. Input and output triggers can be set to any of the six lines, but they cannot use the same line. For example, if you select line #1 for input triggers, then output triggers must use one of the other five lines (#2 through #6). During operation in the channel layer, each Trigger Link input trigger will close a channel in the scan. After the relay settles, and the user programmed DELAY (see paragraph 4.7) times out, the Model 7001 will output a Trigger Link trigger (typically to a DMM to make a measurement). The channel layer is configured using the CONFIGURE SCAN menu (see paragraph 4.8.1).

The scan layer and/or arm layer can also be programmed for TRIGGER LINK; Scan Spacing is set to TRIGLINK, and ARM SPACING is set to TRIGLINK. When using Trigger Link in these layers, you must also select input and output lines as you did in the channel layer. Keep in mind that you can use the same lines in the scan and arm layers that you selected in the channel layer.

Asynchronous Trigger Link example #1

In a typical test system, you may want to close a channel and then measure the DUT connected to that channel with a meter. Such a test system is shown in Figure 4-19 which uses a Model 7011 multiplexer card to switch 10 DUTs to a meter that is equipped with Trigger Link.

The Trigger Link connections for this test system are shown in Figure 4-20. Trigger Link of the Model 7001 is connected to Trigger Link of the meter. Notice that only one Trigger Link cable is needed.

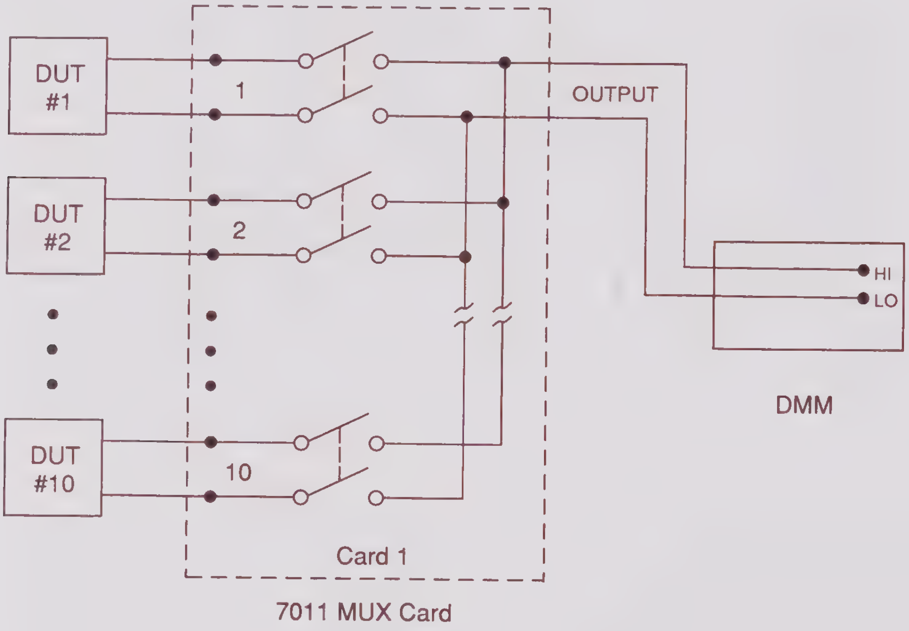

DUT #1
DUT #2
DUT #10
1
2
10
OUTPUT
HI
LO
DMM
Card 1
7011 MUX Card

Figure 4-19
DUT test system

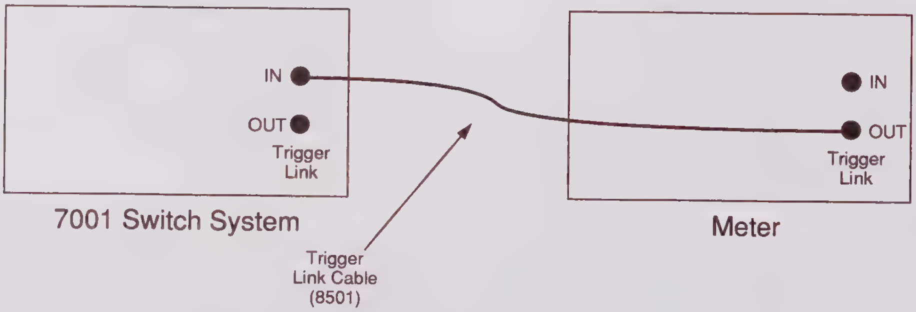

IN
OUT
Trigger Link
7001 Switch System
IN
OUT
Trigger Link
Meter
Trigger Link Cable (8501)

Figure 4-20
Trigger Link connections (asynchronous example #1)

For this example, the Model 7001 and the meter are configured as follows:

Model 7001:

Scan List = 1!1-1!10,

Arm Layer:
  Arm Spacing = Immediate*
  Arm Count = 1*
  Arm Trigger Control = Acceptor*

Scan Layer:
  Scan Spacing = Immediate*
  Number of Scans = 1
  Scan Trigger Control = Acceptor*

Channel Layer:
  Channel Spacing = TrigLink
  Trigger Link Mode = Asynchronous
  Input Line = #2
  Output Line = #1
  Channel Trigger Control = Source*
  Number of Channels = Use Scanlist Length*

* Indicates that the setting is the RESET (and factory) default condition.

Meter:

Arm Layer:
  Arm Source = Immediate
  Arm Count = 1
  Arm Trigger Control = Acceptor

Scan Layer:
  Scan Source = Immediate
  Scan Count = 1
  Scan Trigger Control = Acceptor

Measure Layer:
  Measure Source = TrigLink
  Trigger Link Mode = Asynchronous
  Input Line = #1
  Output Line = #2
  Measure Trigger Control = Acceptor
  Measure Count = 10

Notice that Channel Trigger Control of the Model 7001 is set for Source. With this selection, scan operation will initially bypass the need for a Trigger Link trigger to close the first channel. Since arm spacing and scan spacing are set for Immediate, the scan will start immediately as soon as the scanner is taken out of the idle state by pressing the STEP key (assuming the meter is also out of the idle state).

To run the test simply press TRIG on the meter to take it out of the idle state and then press STEP on the Model 7001. The following explanation on operation is referenced to the operation model shown in Figure 4-21.

Ⓐ Pressing TRIG takes the meter out of the idle state and places meter operation at point A in the flowchart where it is waiting for a Trigger Link trigger. Note that since both the arm layer and scan layer are programmed for Immediate Source, operation immediately drops down to the measure layer at point A.

Ⓑ Pressing STEP takes the Model 7001 out of the idle state and places operation at point B in the flowchart. Since both the arm and scanner layers are programmed for Immediate Spacing, operation drops down to the channel layer at point B.

Ⓒ Since Channel Trigger Control is set for Source, the scan will not wait at point B for a trigger. Instead it will bypass "Wait for Trigger Link Trigger" and close the first channel (point C). Note that the Bypass is only in effect on the first pass through the model.

Ⓓ After the relay settles, the Model 7001 will output a Trigger Link trigger pulse (point D). Since the instrument is programmed to scan 10 channels, operation will loop back up to point B where it will wait for an input trigger. Note that Bypass is no longer in effect.

Ⓔ & Ⓕ Remember that meter operation is at point A waiting for a trigger. The output trigger from the Model 7001 triggers the meter to measure DUT #1 (point E). After the measurement is completed, the meter will output a trigger pulse (point F) and then loop back to point A where it will wait for another input trigger.

The trigger applied to the Model 7001 from the meter closes the next channel in the scan which in turn triggers the meter to measure the next DUT. This process continues until all 10 channels are scanned and measured.

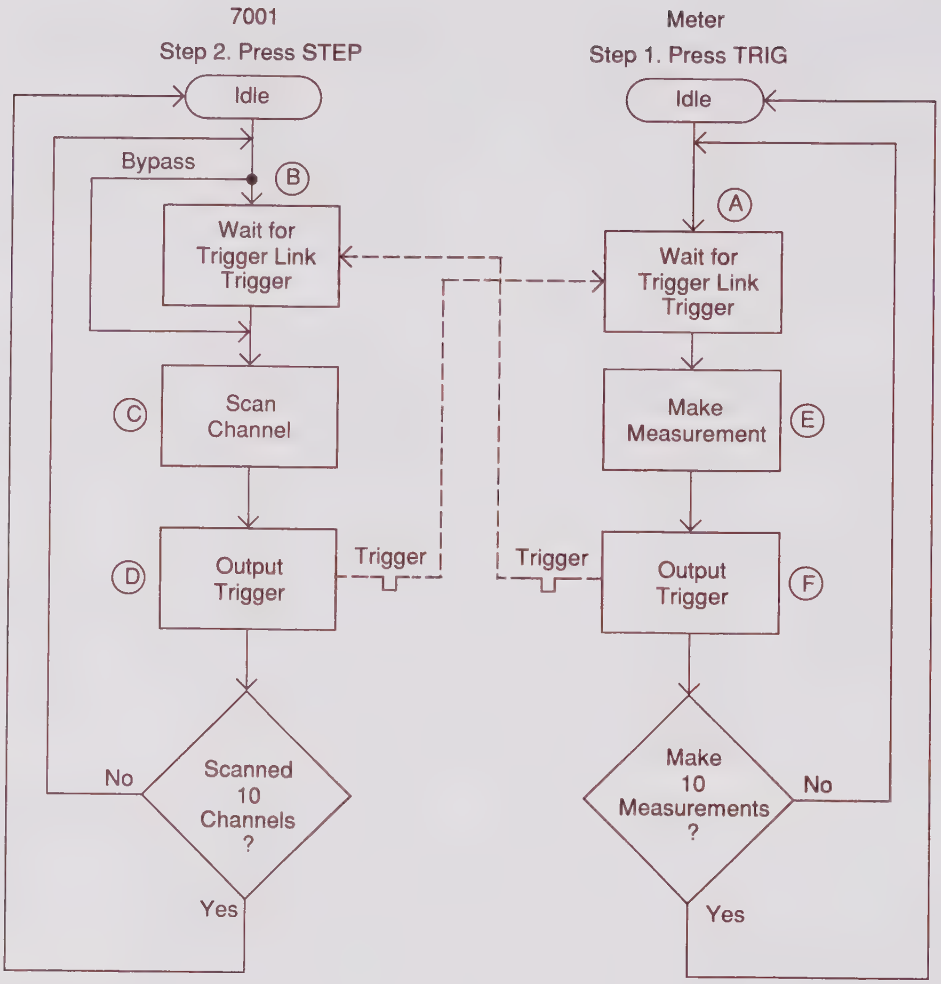

7001
Step 2. Press STEP
Idle
Bypass
B
Wait for Trigger Link Trigger
C
Scan Channel
D
Output Trigger
Trigger
Scanned 10 Channels ?
No
Yes
Meter
Step 1. Press TRIG
Idle
A
Wait for Trigger Link Trigger
Make Measurement
E
Output Trigger
F
Trigger
Make 10 Measurements ?
No
Yes

Figure 4-21
Operation model for asynchronous Trigger Link example #1

External Triggering and Trigger Link—As previously mentioned, the trigger pulses for the asynchronous Trigger Link are identical to the trigger pulses used for External Triggering. The only thing that prevents them from being used together are connection incompatibilities. Trigger Link uses micro 8-pin DIN connectors while External Triggering uses BNC connectors.

This connection problem can be resolved by using the Model 8502 Trigger Link Adapter. The adapter has two micro 8-pin DIN connectors and six BNC connectors. The DIN connectors connect directly to a Trigger Link connector on the Model 7001 using a trigger link cable. The BNC connectors mate directly to the External Triggering BNC connectors on other instruments using standard male BNC to BNC cables.

Figure 4-22 shows how a Keithley Model 196 can be connected to the Trigger Link of the Model 7001 using the adapter. With this adapter, the Model 196 could be substituted for the meter with Trigger Link in the previous example (Asynchronous Trigger Link Example #1). With the Model 196 set for external triggering, the test would start when STEP on the Model 7001 is pressed.

Asynchronous Trigger Link example #2

In this example, the test system (Figure 4-23) includes a Model 196 DMM to measure each DUT at two different bias levels that are provided by the Model 230 voltage source. With the source set to the first voltage level, the 10 channels will be scanned and measured. The source will then be set to the second voltage level and the 10 channels will again be scanned and measured.

Since this example uses instruments that do not have Trigger Link (Model 196 and 230), the Model 8502 Trigger Link Adapter is required. Connections are shown in Figure 4-24.

For this example, the Models 196 and 230 are programmed for External Triggering and the Model 230 is set to source the first voltage level. The Model 7001 is configured as follows:

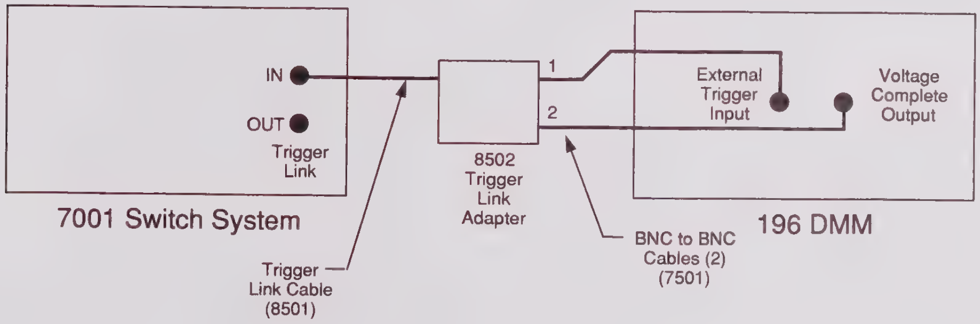


Figure 4-22
Connections using Trigger Link adapter

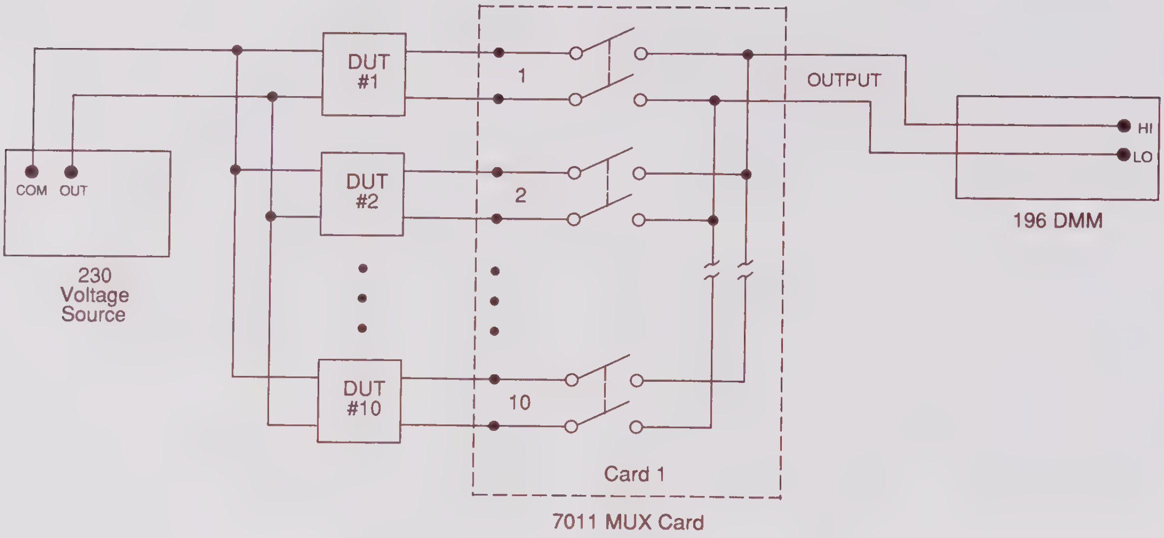

DUT #1
DUT #2
DUT #10
1
2
10
COM
OUT
230 Voltage Source
OUTPUT
HI
LO
196 DMM
Card 1
7011 MUX Card

Figure 4-23
DUT test system (asynchronous example #2)

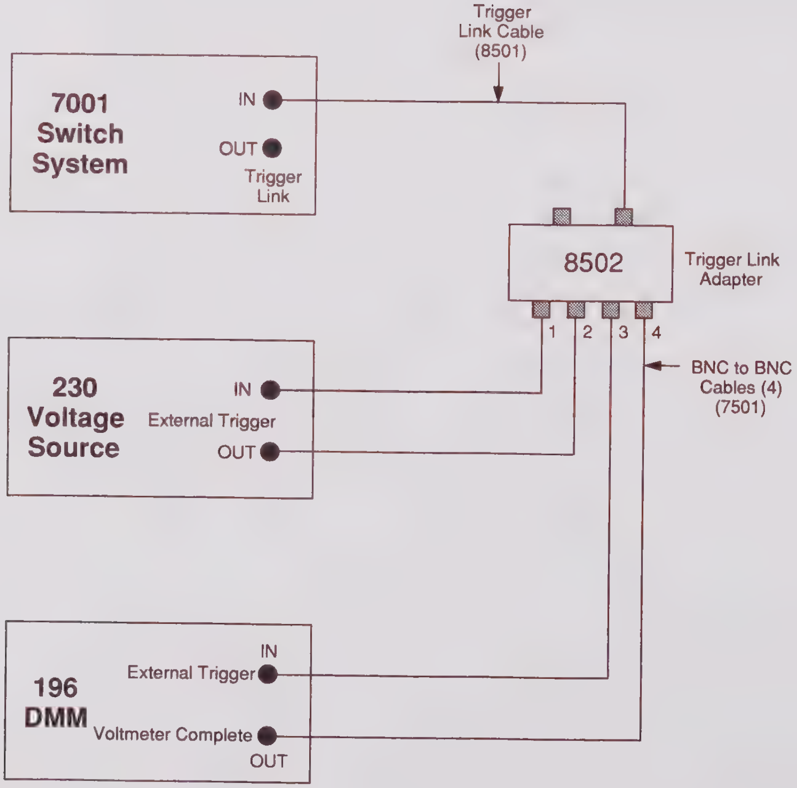

Trigger Link Cable (8501)
7001 Switch System
IN
OUT
Trigger Link
8502
Trigger Link Adapter
1
2
3
4
BNC to BNC Cables (4) (7501)
230 Voltage Source
IN
External Trigger
OUT
196 DMM
IN
External Trigger
Voltmeter Complete
OUT

Figure 4-24
Trigger Link connections (asynchronous example #2)

Model 7001:

Scan List = 1!1-1!10,

Arm Layer:
  Arm Spacing = Immediate*
  Arm Trigger Control = Acceptor*
  Arm Count = 1*

Scan Layer:
  Scan Spacing = TrigLink
  Input Line = # 2
  Output Line = #1
  Scan Trigger Control = Source
  Number of Scans = 2

Channel Layer:
  Channel Spacing = TrigLink
  Trigger Link Mode = Asynchronous
  Input Line = #4
  Output Line = #3
  Channel Trigger Control = Source*
  Number of Channels = Use Scanlist Length*

* Indicates that the setting is the RESET (and factory) default condition.

To run the test, simple press STEP on the Model 7001. The following explanation on operation is referenced to the operation model shown in Figure 4-25.

Ⓐ Pressing STEP takes the Model 7001 out of the idle state and places operation at point A in the flowchart. Since the arm layer is programmed for Immediate Spacing, operation drops down to the scan layer at point A.

Ⓑ Since Scan Trigger Control is set for Source, the scan will not wait at point A for a trigger. Instead, it will bypass "Wait for Trigger Link Trigger" and proceed to point B. Note that this Bypass is only in effect on the first pass through the model.

Ⓒ Since Channel Trigger Control is also set for Source, the scan will not wait at point B for a trigger. Instead it will bypass "Wait for Trigger Link Trigger" and close the first channel (point C). Note that this Bypass is only in effect on the first pass through the model.

Ⓓ After the relay settles, the Model 7001 will output a Trigger Link trigger pulse (point D). Since the instrument is programmed to scan 10 channels, operation will loop back up to point B where it will wait for an input trigger. Note that Bypass is no longer in effect

Ⓔ The trigger pulse from the Model 7001 will trigger the Model 196 to make a measurement of DUT #1. After the measurement is completed, the DMM will output a trigger pulse (point E).

The trigger applied to the Model 7001 from the DMM closes the next channel in the scan which in turn triggers the meter to measure the next DUT. This process continues until all 10 channels are scanned and measured.

Ⓕ After the last channel is scanned and measured, operation proceeds to point F where the Model 7001 outputs a trigger pulse. Since the Model 7001 is programmed to perform two scans, its operation will loop back up to point A where it will wait for an input trigger. Note that Bypass is no longer in effect.

Ⓖ The trigger pulse from the Model 7001 triggers the Model 230 to output the next programmed voltage level. After the voltage level is set, the Model 230 will output a trigger pulse (point G).

The trigger pulse applied to the Model 7001 from the Model 230 places operation at point B. The Bypass is again in effect because this is the beginning of a new scan. This allows operation to drop down to point C where the first channel will again be closed and eventually measured. As previously explained all ten channels are scanned and measured.

After the last channel of the second scan is closed and measured, the Model 7001 returns to the idle state.

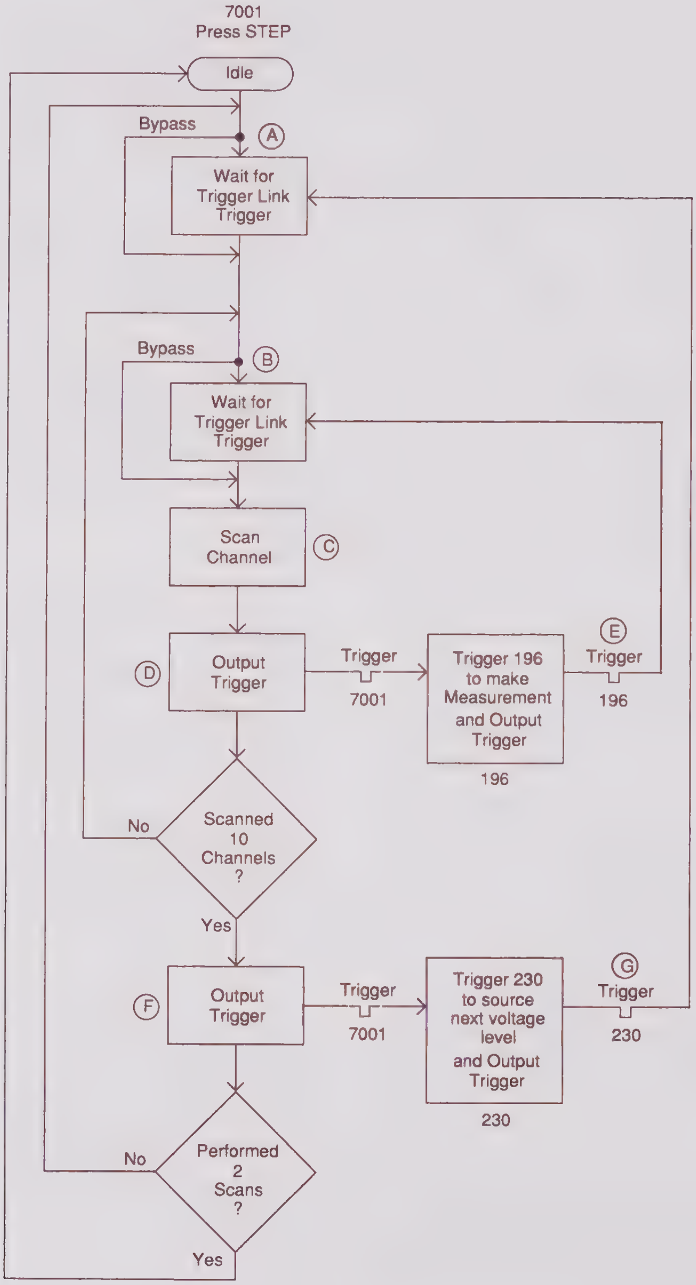

7001
Press STEP
Idle
Bypass
A
Wait for Trigger Link Trigger
Bypass
B
Wait for Trigger Link Trigger
Scan Channel
C
D
Output Trigger
Trigger
7001
Trigger 196 to make Measurement and Output Trigger
196
E
Trigger
196
No
Scanned 10 Channels ?
Yes
F
Output Trigger
Trigger
7001
Trigger 230 to source next voltage level and Output Trigger
230
G
Trigger
230
No
Performed 2 Scans ?
Yes

Figure 4-25
Operation model for asynchronous Trigger Link example #2

4.11.2 Semi-synchronous operation

In the Semi-Synchronous Trigger Link mode all triggering (input and output) in the test system is controlled by a single line. When the normally high (+5V) trigger line is pulled low (0V), a trigger occurs on the negative-going edge. When the trigger line is released, a trigger occurs on the positive-going edge (see Figure 4-26). The advantage of this single line trigger is that as long as one of the instruments in the system holds the line low, the trigger is suppressed. In other words, the trigger will not occur until all instruments in the system are ready.

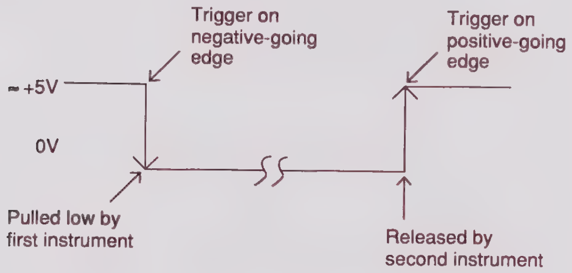

Trigger on negative-going edge
Trigger on positive-going edge
≈ +5V
0V
Pulled low by first instrument
Released by second instrument

Figure 4-26
Semi-synchronous trigger link pulse specifications

For example, assume that a meter (equipped with Trigger Link) is connected to two Model 7001s for semi-synchronous operation as shown in Figure 4-27. All three instruments are programmed to use trigger line #1. The two Model 7001s have relay settling times of 10msec and 50msec respectively.

Assume that the meter initially performs a measurement. After the reading is done, the meter will drive the trigger line low. The negative-going edge will trigger both Model 7001s to close a channel. While the Model 7001s are in the process of closing a channel, they will hold the trigger line low. Ten milliseconds after switch closure, the first Model 7001 will release the trigger line. However, the second Model 7001 will continue to hold the line low since it is not finished. Fifty milliseconds after switch closure, the second Model 7001 will release the trigger line. The positive-going edge will trigger the meter to perform a measurement and subsequently pull the trigger line back down to close the next channels. This process continues until all channels are scanned and measured.

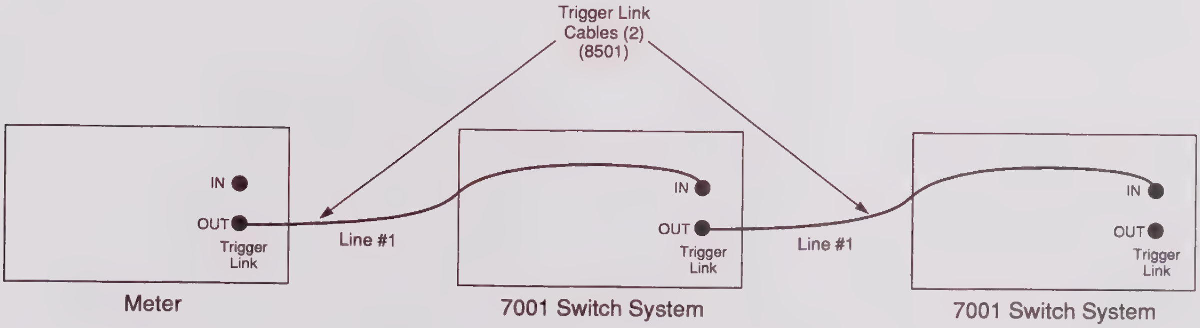

Trigger Link Cables (2) (8501)
IN
OUT
Trigger Link
Meter
Line #1
IN
OUT
Trigger Link
7001 Switch System
Line #1
IN
OUT
Trigger Link
7001 Switch System

Figure 4-27
Typical semi-synchronous mode connections

Semi-synchronous Trigger Link example

This example uses the same test system (Figure 4-19) that was used for the Asynchronous Trigger Link Example #1. However, triggering will be done using the Semi-Synchronous mode. Trigger Link connections are shown in Figure 4-28.

The two instruments are configured as follows:

Model 7001:

Scan List = 1!1-1!10,

Arm Layer:
Arm Spacing = Immediate*
Arm Count = 1*
Arm Trigger Control = Acceptor*

Scan Layer:
Scan Spacing = Immediate*
Number of Scans = 1
Scan Trigger Control = Acceptor*

Channel Layer:
Channel Spacing = TrigLink
Trigger Link Mode = Semi-Synchronous
Semi-Sync Line = #1
Trigger Control = Source*
Number of Channels = Use Scanlist Length*

* Indicates that the setting is the RESET (and factory) default condition

Meter:

Arm Layer:
Arm Source = Immediate
Arm Count = 1
Arm Trigger Control = Acceptor

Scan Layer:
Scan Source = Immediate
Scan Count = 1
Scan Trigger Control = Acceptor

Measure Layer:
Measure Source = TrigLink
Trigger Link Mode = Semi-Synchronous
Semi-Sync Line = #1
Trigger Control = Acceptor
Measure Count = 10

To run the test, simply press TRIG on the meter to take it out of the idle state and then press STEP on the Model 7001. The following explanation on operation is referenced to the operation model shown in Figure 4-29.

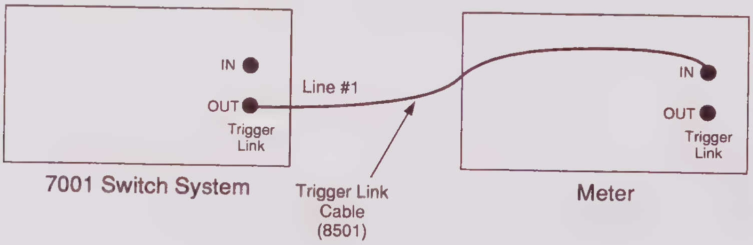


Figure 4-28
Trigger Link connections (semi-synchronous example)

Ⓐ Pressing TRIG takes the meter out of the idle state and places meter operation at point A in the flowchart where it is waiting for a Trigger Link trigger. Note that since both the arm layer and scan layer are programmed for Immediate Source, operation immediately drops down to the measure layer at point A.

Ⓑ Pressing STEP takes the Model 7001 out of the idle state and places operation at point B in the flowchart. Since both the arm and scanner layers are programmed for Immediate Spacing, immediately and operation drops down to the channel layer at point B.

Ⓒ Since Channel Trigger Control is set for Source, the scan will not wait at point B for a trigger. Instead it will bypass "Wait for Trigger Link Trigger" and close the first channel (point C). Note that the Bypass is only in effect on the first pass through the model.

Ⓓ After the relay settles, the Model 7001 will pull down the Trigger Link trigger line (point D). Since the instrument is programmed to scan 10 channels, operation will loop back up to point B where it will wait for an input trigger. Note that Bypass is no longer in effect.

Ⓔ & Ⓕ Remember that meter operation is at point A waiting for a trigger. When the trigger line was pulled low by the Model 7001, the leading negative-going edge triggers the meter to measure DUT #1 (point E). Note that the meter holds the trigger line low. After the measurement is completed, the meter will release the trigger line (point F) and then loop back to point A where it will wait for another input trigger.

When the meter released the trigger line, the leading positive-going edge triggers the Model 7001 to close the next channel in the scan which in turn pulls the trigger line low triggering the meter to measure the next DUT. This process continues until all 10 channels are scanned and measured.

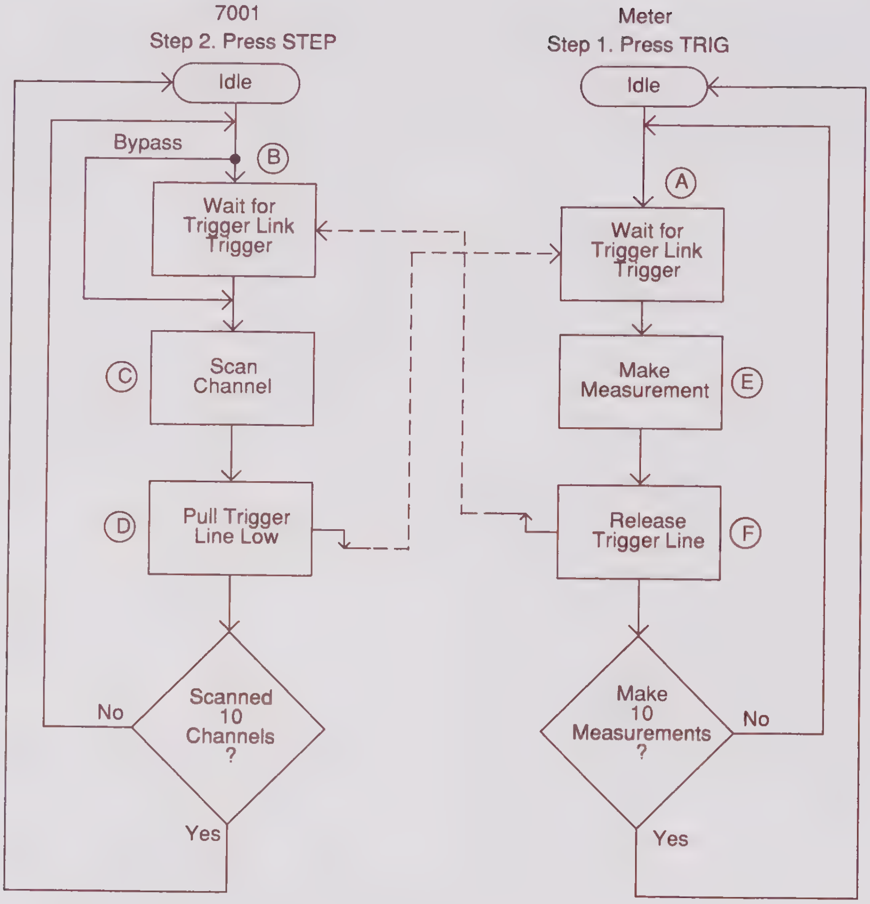

7001
Step 2. Press STEP
Meter
Step 1. Press TRIG
Idle
Idle
Bypass
B
A
Wait for Trigger Link Trigger
Wait for Trigger Link Trigger
C
Scan Channel
Make Measurement
E
D
Pull Trigger Line Low
Release Trigger Line
F
No
Scanned 10 Channels ?
Yes
Make 10 Measurements ?
No
Yes

Figure 4-29
Operation model for semi-synchronous Trigger Link example

4.12 DUT test system using two switching mainframes

The following example explains how to configure and operate a DUT test system using two switching mainframes (7001s) and a DMM (2001 or 2002).

Assume there are four 10-channel multiplexer switching cards (Model 7156 General Purpose Mux Cards) installed in the switching mainframes (two cards in each mainframe) for a total of forty 2-pole channels. This test system (shown in Figure 4-30) will scan and measure the forty 2-pole channels twice (two scans). The Trigger Link connections for this test system are shown in Figure 4-31. For this example, the DMM and switching mainframes (7001s) are configured as described in the following paragraphs.

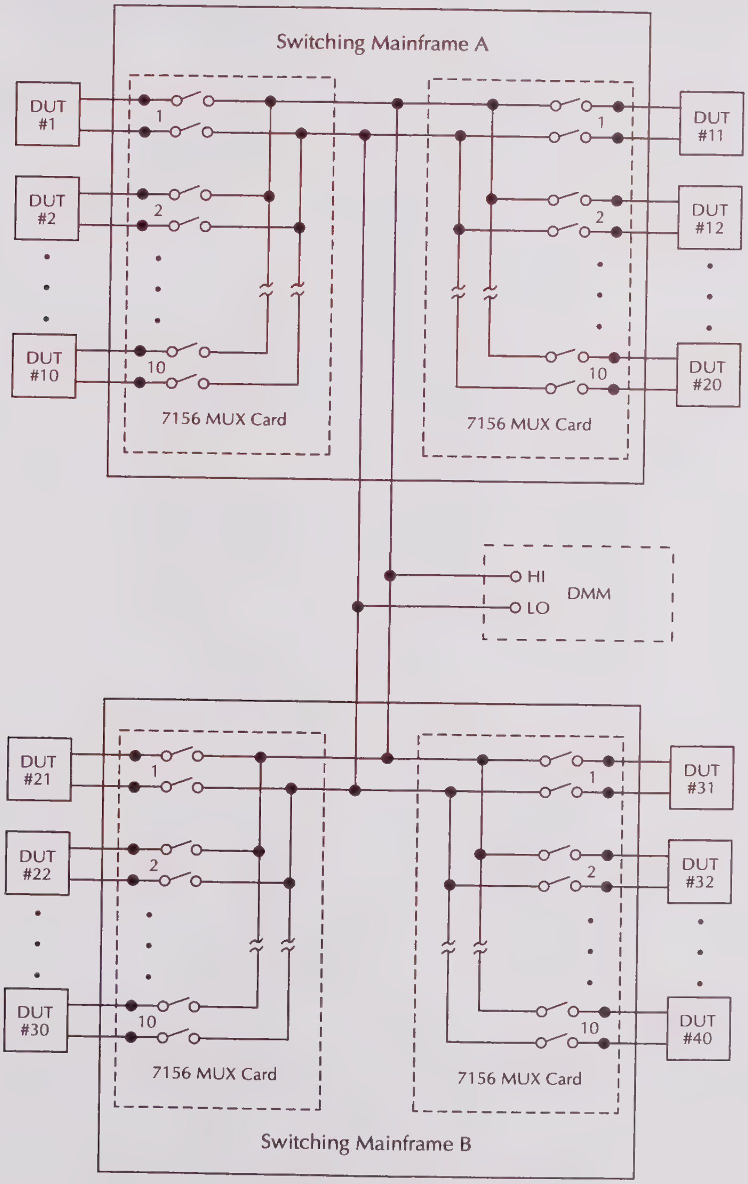

Switching Mainframe A
DUT #1
DUT #2
DUT #10
1
2
10
7156 MUX Card
DUT #11
DUT #12
DUT #20
7156 MUX Card
HI
LO
DMM
DUT #21
DUT #22
DUT #30
7156 MUX Card
DUT #31
DUT #32
DUT #40
7156 MUX Card
Switching Mainframe B

Figure 4-30
DUT test system

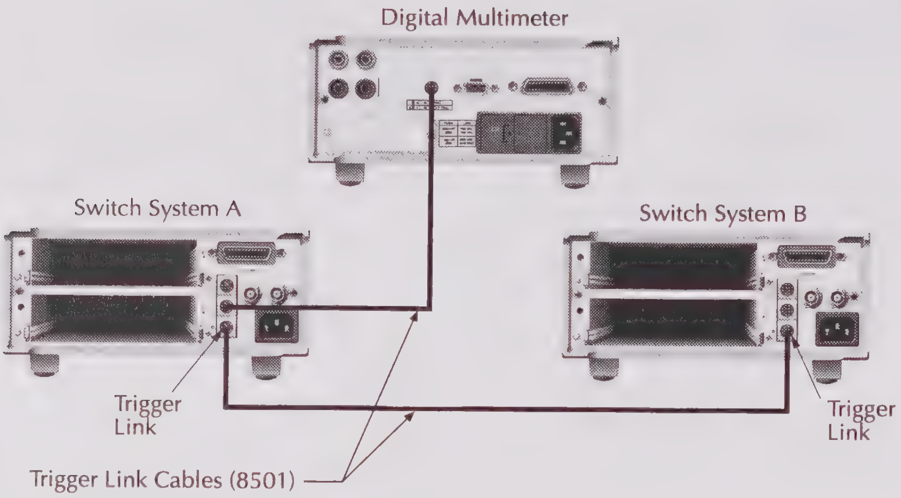

Digital Multimeter
Switch System A
Switch System B
Trigger Link
Trigger Link
Trigger Link Cables (8501)

Figure 4-31
Trigger link connections

4.12.1 DMM settings

Data store: Arm to store 80 readings
Trigger Configuration:

Arm Layer:	Source	Immediate*
	Count	1*
	Control	Acceptor*
Scan Layer:	Source	Immediate*
	Delay	0.0*
	Count	1
	Control	Acceptor*
Measure Layer:	Source	TrigLink
	Trigger Link Mode	Asynchronous*
	Input Trigger	Line 2*
	Output Trigger	Line 1*
	Delay	0.2
	Count	Infinite*
	Control	Acceptor*

*BENCH RESET default setting

4.12.2 Switching mainframe A settings (7001)

Scan List = 1!1-1!10, 2!1-2!10, M1,

NOTE

M1 is a “dummy” channel configured to open all channels. This lets the last channel in a mainframe open before closing the first channel in the other mainframe.

Card Delay = 0.0
Pole Mode = 2-Pole
Scan Configuration:

Arm Control:	Spacing	TrigLink
	Input Trigger	Line 5
	Output Trigger	Line 6
	Count	1*
	Control	Source
Scan Control:	Spacing	TrigLink
	Input Trigger	Line 3
	Output Trigger	Line 4
	Count	2
	Control	Source
Channel Control:	Spacing	TrigLink
	Trigger Link Mode	Asynchronous*
	Input Trigger	Line 1*
	Output Trigger	Line 2*
	Count	ScanList*
	Control	Source*

*RESET default setting

4.12.3 Switching mainframe B settings (7001)

Scan List = 1!1-1!10, 2!1-2!10, M1,

NOTE

M1 is a “dummy” channel configured to open all channels. This lets the last channel in a mainframe open before closing the first channel in the other mainframe.

Card Delay = 0.0
Pole Mode = 2-Pole
Scan Configuration:

Arm Control: Spacing		TrigLink
Input Trigger		Line 4
Output Trigger		Line 3
Count		2
Control		Source

Scan Control:		Spacing	TrigLink
	Input Trigger	Line 4	
	Output Trigger	Line 3	
	Count	1	
	Control	Source	

Channel Control: Spacing		TrigLink
	Trigger Link Mode	Asynchronous*
	Input Trigger	Line 1*
	Output Trigger	Line 2*
	Count	ScanList*
	Control	Source*

*RESET default setting

4.12.4 Run DUT test SYSTem

1. Press STEP on Switching Mainframe B.
2. Press STEP on Switching Mainframe A.
3. Observe the scanning sequence. The test will stop after two scans of the 40 channels are finished.
4. Press RECALL on the DMM to display the stored readings.

NOTE

The “Trigger ignored” message will appear on the DMM when the scan sequence switches from one switching mainframe to the other. This is caused by extraneous triggers and does not affect the integrity of the testing process. The ignored triggers prevent the “dummy” M1 channels from being measured.

4.12.5 Operation details

The detailed step-by-step testing process is explained as follows using the flowchart in Figure 4-32. The block diagram in Figure 4-33 helps track input and output triggers. While triggers are shown in the flowchart, the block diagram clarifies the source and destination of each trigger. Refer to both drawings for the following discussion.

NOTE

Once started, the entire testing process is controlled by input and output triggering (via Trigger Link) between the three instruments. Keep in mind the following points about TRIGLINK triggering:

- A trigger model layer can only respond to an input trigger if TRIGLINK is selected.
- The arm layer and scan layer of a trigger model can only output a trigger if TRIGLINK is selected and the Source bypass is enabled. Output triggers for the channel layer (switching mainframe) and measure layer (DMM) are always enabled if TRIGLINK is selected.
- With the Source bypass enabled, operation is not held up (waiting for trigger) on the initial pass through that trigger model layer.

1. The DMM setup places its operation at point D1 (D for DMM) where it waits for an input trigger.
2. Pressing the STEP key on Mainframe B places its operation at point B1 (B for Mainframe B) where it also waits for an input trigger.
3. When the STEP key on Mainframe A is pressed, its operation drops down into the Channel Layer and the scanning sequence begins. This occurs because all three layers of the trigger model are configured to use the trigger link and the Source bypass is enabled.
4. After the first channel is closed (Scan Channel), an output trigger (via line 2) is sent to the DMM. Mainframe A operation then loops up to point A1 (A for Mainframe A) where it waits for an input trigger.
5. After the DMM receives the trigger, it performs a measurement, stores the reading, and then outputs a trigger (via line 1) back to Mainframe A to scan the next channel. Note that DMM operation always returns to point D1 where it waits for another input trigger.
6. The triggering process between the DMM and the channel layer of Mainframe A continues until all channels in the scan list (DUTs 1 through 20) are scanned and measured. Note that the last channel in the scan list is M1, which opens all channels.
7. After channel M1 is scanned, Mainframe A passes the testing process to Mainframe B by sending a trigger (via line 4) to it. Mainframe A operation loops up to point A2 where it waits for a trigger. Note that channel M1 is not measured because the trigger sent to the DMM is ignored ("Trigger ignored" message displayed).
8. After Mainframe B receives the trigger, operation drops down to the channel layer where the channels in its scan list (DUTs 21 through 40) are scanned and measured. This scan/measure process operates the same as the one for Mainframe A (steps 4, 5, and 6).
9. After channel M1 of Mainframe B is scanned, the testing process is passed back to Mainframe A by sending it an output trigger (via line 3). Mainframe B operation loops back up to point B1 where it waits for a trigger. Again, note that channel M1 is not measured because the trigger sent to the DMM is ignored.
10. After Mainframe A receives the trigger at point A2, its operation drops down into the channel layer where its channels (DUTs 1 through 20) are again scanned and measured.
11. The testing process is again passed on to Mainframe B by sending it a trigger. Mainframe A then goes into idle.
12. After Mainframe B receives the trigger (at point B1), its operation drops down into the channel layer where its channels (DUTs 21 through 40) are again scanned and measured. Mainframe B then goes into idle.

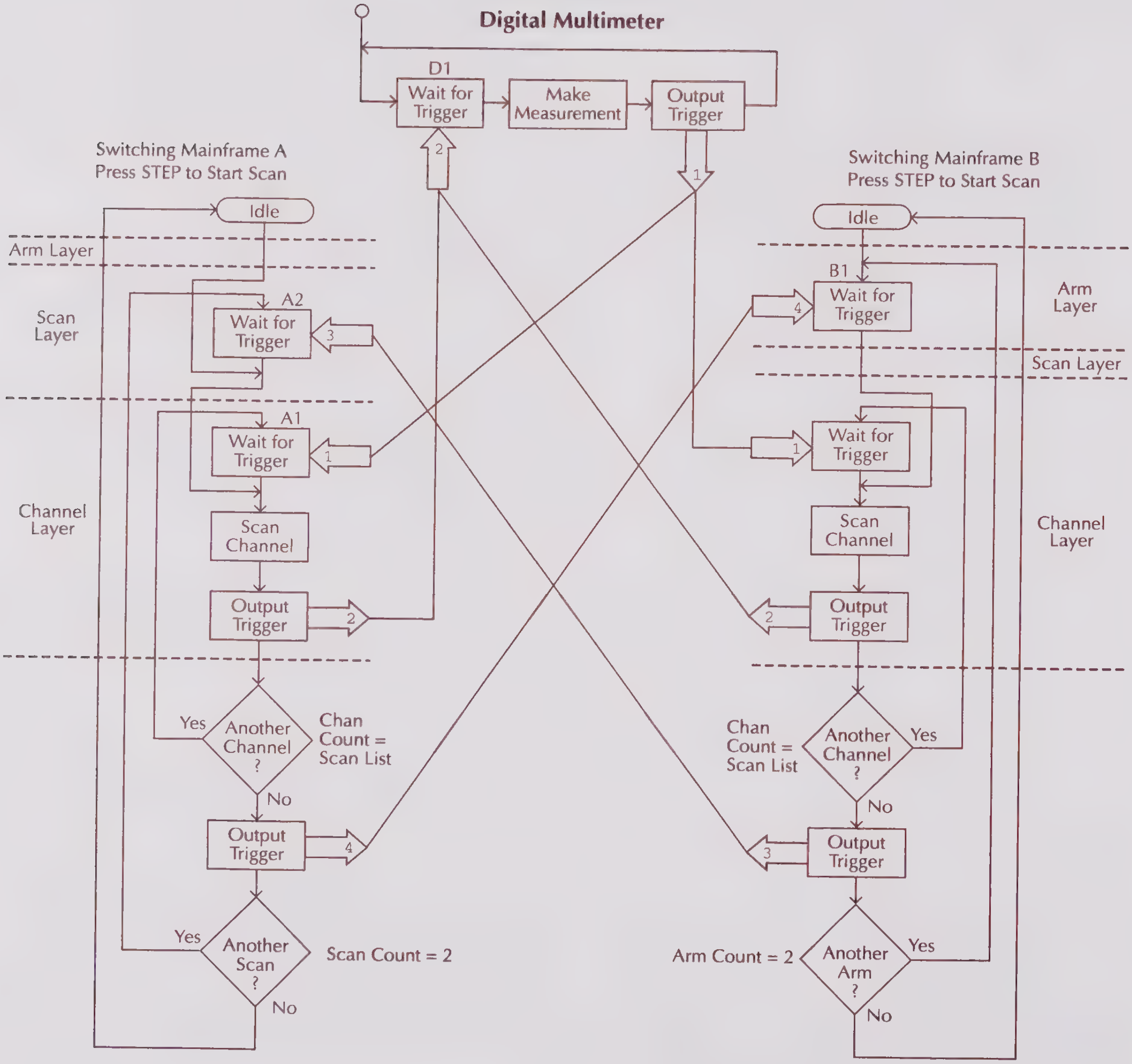

Digital Multimeter
D1
Wait for Trigger
Make Measurement
Output Trigger
Switching Mainframe A
Press STEP to Start Scan
Idle
Arm Layer
Scan Layer
A2
Wait for Trigger
A1
Wait for Trigger
Channel Layer
Scan Channel
Output Trigger
Yes
Another Channel ?
Chan Count = Scan List
No
Output Trigger
Yes
Another Scan ?
Scan Count = 2
No
Switching Mainframe B
Press STEP to Start Scan
Idle
B1
Wait for Trigger
Arm Layer
Scan Layer
Wait for Trigger
Scan Channel
Channel Layer
Output Trigger
Chan Count = Scan List
Another Channel ?
Yes
No
Output Trigger
Arm Count = 2
Another Arm ?
Yes
No
1
2
3
4

Figure 4-32
Digital multimeter flowchart

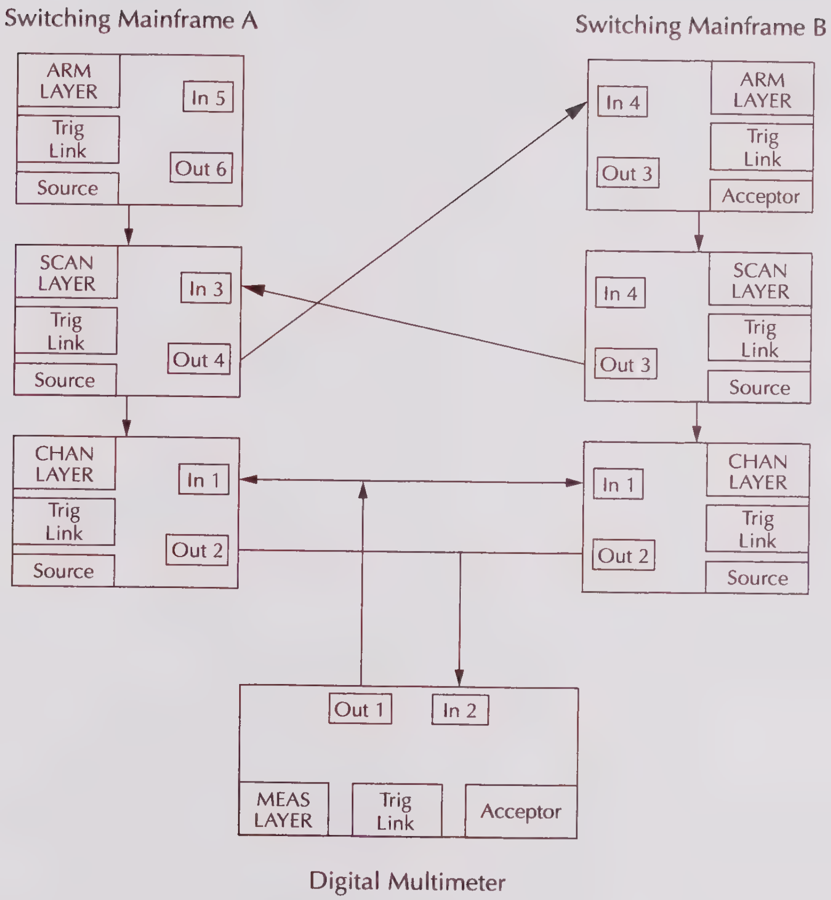

Switching Mainframe A
ARM LAYER
Trig Link
Source
In 5
Out 6
SCAN LAYER
Trig Link
Source
In 3
Out 4
CHAN LAYER
Trig Link
Source
In 1
Out 2
Switching Mainframe B
In 4
Out 3
ARM LAYER
Trig Link
Acceptor
In 4
Out 3
SCAN LAYER
Trig Link
Source
In 1
Out 2
CHAN LAYER
Trig Link
Source
Out 1
In 2
MEAS LAYER
Trig Link
Acceptor
Digital Multimeter

Figure 4-33
Digital multimeter block diagram

5

IEEE-488 Reference

5.1 Introduction

This section contains reference information on programming the Model 7001 over the IEEE-488 bus and is organized as follows:

5.2 IEEE-488 bus connections: Explains instrument connections to the IEEE-488 bus.

5.3 Primary address selection: Explains how to set the primary address from the front panel.

5.4 Controller programming: Summarizes programming statements using HP BASIC 4.0.

5.5 Front panel aspects of IEEE-488 operation: Covers status indicators, messages that pertain to bus operation, and the use of the LOCAL key.

5.6 Status structure: Explains the various registers and queues that make up the status structure of the Model 7001.

5.7 Trigger model: Explains the scan process (Trigger Model) over the IEEE- 488 bus.

5.8 General bus commands: Covers the general IEEE-488 commands required for basic operations, such as placing the unit in remote.

5.9 Programming syntax: Covers the syntax rules for common commands and SCPI commands.

5.10 Common commands: Covers the IEEE-488.2 common commands used by the Model 7001.

5.11 SCPI command subsystems: Covers the SCPI commands used by the Model 7001.

The IEEE-488 is an instrumentation data bus with hardware and programming standards originally adopted by the IEEE (Institute of Electrical and Electronic Engineers) in 1975 and given the IEEE-488 designation. In 1978 and 1987, the standards were upgraded to IEEE-488-1978 and IEEE-488.1-1987, respectively. The Model 7001 conforms to these standards.

The Model 7001 also conforms to the IEEE-488.2-1987 standard and the SCPI 1992 (Standard Commands for Programmable Instruments) standard. IEEE-488.2 defines a syntax for sending data to and from instruments, how an instrument interprets this data, and what registers should exist to record the state of the instrument. This subset of commands (common commands) is used to perform basic operations, such as reading status registers, triggering measurements, and resetting the device.

The SCPI standard defines a command language protocol. It goes one step farther than IEEE-488.2 and defines a standard set of commands to control every programmable aspect of an instrument. It also defines what format the parameters for those commands should be in and the format for values returned by the instruments.

5.2 IEEE-488 bus connections

The Model 7001 can be connected to the IEEE-488 bus through a cable equipped with standard IEEE-488 connectors, an example is shown in Figure 5-1. The connector can be stacked to allow a number parallel connections to one instrument. Two screws are located on each connector to ensure that connections remain secure. Current standards call for metric threads, which are identified with dark colored screws. Earlier versions had different screws, which were silver colored. Do not attempt to use these types of connectors on the instrument, which is designed for metric threads.

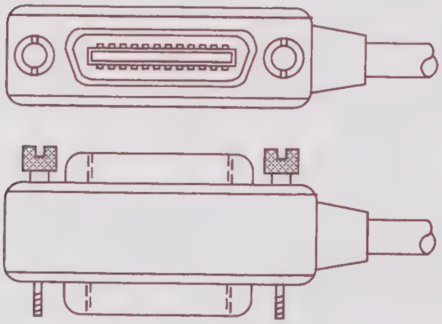


Figure 5-1
IEEE-488 connector

A typical connecting scheme for a multi-unit test system is shown in Figure 5-2. Although any number of connectors could theoretically be stacked on one instrument, it is recommended that you stack no more than three connectors on any one unit to avoid possible mechanical damage.

NOTE

In order to minimize interference caused by electromagnetic radiation, it is recommended that only shielded IEEE-488 cables be used. The Models 7007-1 and 7007-2 shielded IEEE-488 cables are available from Keithley.

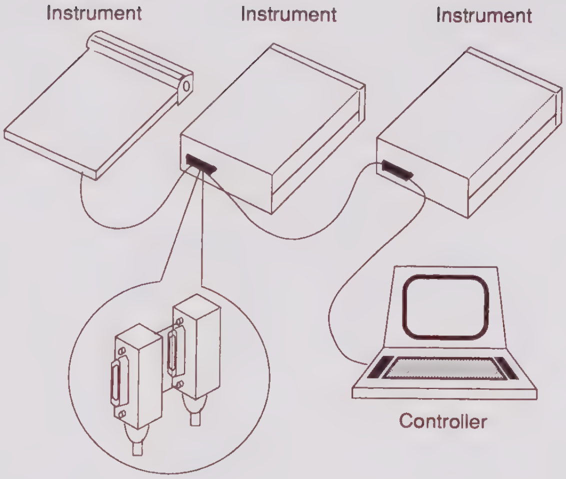


Figure 5-2
IEEE-488 connections

Connect the Model 7001 to the IEEE-488 bus as follows:

1. Line up the cable connector with the connector located on the rear panel. The connector is designed so that it will fit only one way. Figure 5-3 shows the location of the IEEE-488 connector on the instrument.
2. Tighten the screws securely, but do not overtighten them.
3. Add additional connectors from other instruments, as required.
4. Make certain that the other end of the cable is properly connected to the controller. Most controllers are equipped with an IEEE-488 style connector, but a few may require a different type of connecting cable. Consult the instruction manual for your controller for the proper connecting method.

NOTE

The IEEE-488 bus is limited to a maximum of 15 devices, including the controller. The maximum cable length is 20-meters, or two meters times the number of devices, whichever is less. Failure to observe these limits may result in erratic bus operation.

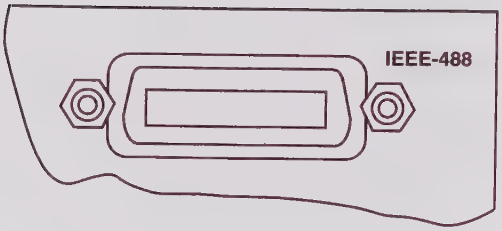


Figure 5-3
IEEE-488 connector location

Custom cables may be constructed by using the information in Table 5-1 and Figure 5-4. Table 5-1 lists the contact assignments for the bus, and Figure 5-4 shows the contact configuration.

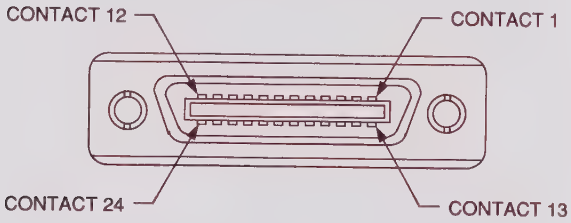


Figure 5-4
Contact assignments

CAUTION

IEEE-488 common is connected to digital common. Maximum voltage between digital common and earth ground is 0V.

Table 5-1
IEEE contact designations

Contact number	IEEE-488 designation	Type
1	DIO1	Data
2	DIO2	Data
3	DIO3	Data
4	DIO4	Data
5	EOI (24)*	Management
6	DAV	Handshake
7	NRFD	Handshake
8	NDAC	Handshake
9	IFC	Management
10	SRQ	Management
11	ATN	Management
12	SHIELD	Ground
13	DIO5	Data
14	DIO6	Data
15	DIO7	Data
16	DIO8	Data
17	REN (24)*	Management
18	Gnd, (6)*	Ground
19	Gnd, (7)*	Ground
20	Gnd, (8)*	Ground
21	Gnd, (9)*	Ground
22	Gnd, (10)*	Ground
23	Gnd, (11)*	Ground
24	Gnd, LOGIC	Ground

*Numbers in parentheses refer to signal ground return of referenced contact number. EOI and REN signal lines return on contact 24.

5.3 Primary address selection

The Model 7001 must receive a listen command before responding to addressed commands. Similarly, the unit must receive a talk command before transmitting data. The Model 7001 is shipped from the factory with a programmed primary address of 7.

The primary address may be set to any value between 0 and 30 as long as address conflicts with other instruments are avoided. Note that controllers are also given a primary address, so do not use that address either. Most frequently, controller addresses are 0 or 21, but you should consult the controller's instruction manual for details. Whatever primary address you choose, you must make certain that it corresponds with the value specified as part of the controller's programming language.

To check the present primary address or to change to a new one, perform the following procedure:

1. Display the MAIN MENU by pressing the MENU key.
2. Use the cursor keys (◀ and ▶) to place the cursor on GPIB and press ENTER. The GPIB SETUP MENU will then be displayed.
3. Use the cursor keys to place the cursor on ADDRESS and press ENTER. The current primary address of the instrument will be displayed. For example, if the instrument is set to primary address 7, the following message will be displayed:

   ADDRESS = 07 (0-30)

4. To retain the displayed address, press EXIT three times to return the instrument to the channel status display state.
5. To change the primary address, use the keypad to display the new address value (0 to 30) and press ENTER. Press EXIT two times to return to the channel status display state.

NOTE

Each device on the bus must have a unique primary address. Failure to observe this precaution will probably result in erratic bus operation.

5.4 Controller programming

The programming instructions covered in this section use examples written with Hewlett-Packard BASIC version 4.0. This language was chosen because of its versatility in controlling the IEEE-488 bus. This section covers those statements that are essential to Model 7001 operation.

NOTE

Controller programming information for using the IBM PC interface through the Capital Equipment Corporation (CEC), I/O Tech, and National IEEE-488 interfaces is located in the Appendix.

A partial list of HP BASIC 4.0 statements is shown in Table 5-2. The statements have a one or three digit argument that must be specified. The first digit is the interface select code, which is set to 7 at the factory. The last two digits of those statements requiring a 3-digit argument specify the primary address.

Those statements with a 3-digit argument show a primary address of 7 (the factory set primary address). For a different address, you would, of course, change the last two digits to the required value. For example, to send a GTL command to a device using a primary address of 17, the following statement would be used: LOCAL 717.

Some of the statements have two forms; the exact configuration depends on the command to be sent over the bus. For example, CLEAR 7 sends a DCL command, while CLEAR 716 sends the SDC command to a device with a primary address of 16.

Table 5-2
HP BASIC 4.0 IEEE-488 statements

Action	BASIC statement
Transmit string to device 07.	OUTPUT 707;A$
Obtain string from device 07.	ENTER 707;A$
Send GTL to device 07.	LOCAL 707
Send SDC to device 07.	CLEAR 707
Send DCL to all devices.	CLEAR 7
Send remote enable.	REMOTE 7
Cancel remote enable.	LOCAL 7
Serial poll device 07.	SPOLL (707)
Send local lockout.	LOCAL LOCKOUT 7
Send GET to device 07.	TRIGGER 707
Send IFC.	ABORT 7

5.5 Front panel aspects of IEEE-488 operation

The following paragraphs discuss aspects of the front panel that are part of IEEE-488 operation, including messages, status indicators, and the LOCAL key.

5.5.1 Error and status messages

Table 4-1 in Section 4 summarizes the error and status messages associated Model 7001 operation. Note that the instrument may be programmed to generate an SRQ, and command queries can be performed to check for specific error conditions.

5.5.2 IEEE-488 status indicators

The REM (remote), TALK (talk), LSTN (listen), and SRQ (service request) annunciators show the present IEEE-488 status of the instrument. Each of these indicators is briefly described below.

REM — As the name implies, this indicator shows when the instrument is in the remote state. Note that REM does not necessarily indicate the state of the REM line, as the instrument must be addressed to listen with REM true before the REM indicator turns on. When the instrument is in remote, all front panel keys except for the LOCAL key are locked out. When REM is turned off, the instrument is in the local state, and front panel operation is restored.

TALK — This indicator is on when the instrument is in the talker active state. The unit is placed in this state by addressing it to talk with the correct MTA (My Talk Address) command. TALK is off when the unit is in the talker idle state. The instrument is placed in the talker idle state by sending it an UNT (Untalk) command, addressing it to listen, or with the IFC (Interface Clear) command.

LSTN — This indicator is on when the Model 7001 is in the listener active state, which is activated by addressing the instrument to listen with the correct MLA (My Listen Address) command. Listen is off when the unit is in the listener idle state. The unit can be placed in the listener idle state by sending UNL (Unlisten), addressing it to talk, or by sending IFC (Interface Clear) over the bus.

SRQ — The instrument can be programmed to generate a service request (SRQ) when one or more errors or conditions occur. When this indicator is on, a service request has been generated. This indicator will stay on until the serial poll byte is read. See paragraph 5.6.8 for details.

5.5.3 LOCAL key

The LOCAL key cancels the remote state and restores local operation of the instrument.

Since all front panel keys except LOCAL are locked out when the instrument is in remote, this key provides a convenient method of restoring front panel operation. Pressing LOCAL also turns off the REM indicator, and returns the display to normal if a user defined message was displayed.

Note that the LOCAL key is also inoperative if the LLO (Local Lockout) command is in effect.

5.6 Status structure

The status register structure of the Model 7001 is shown in Figure 5-5. The following information will explain the various registers and queues that make up this structure.

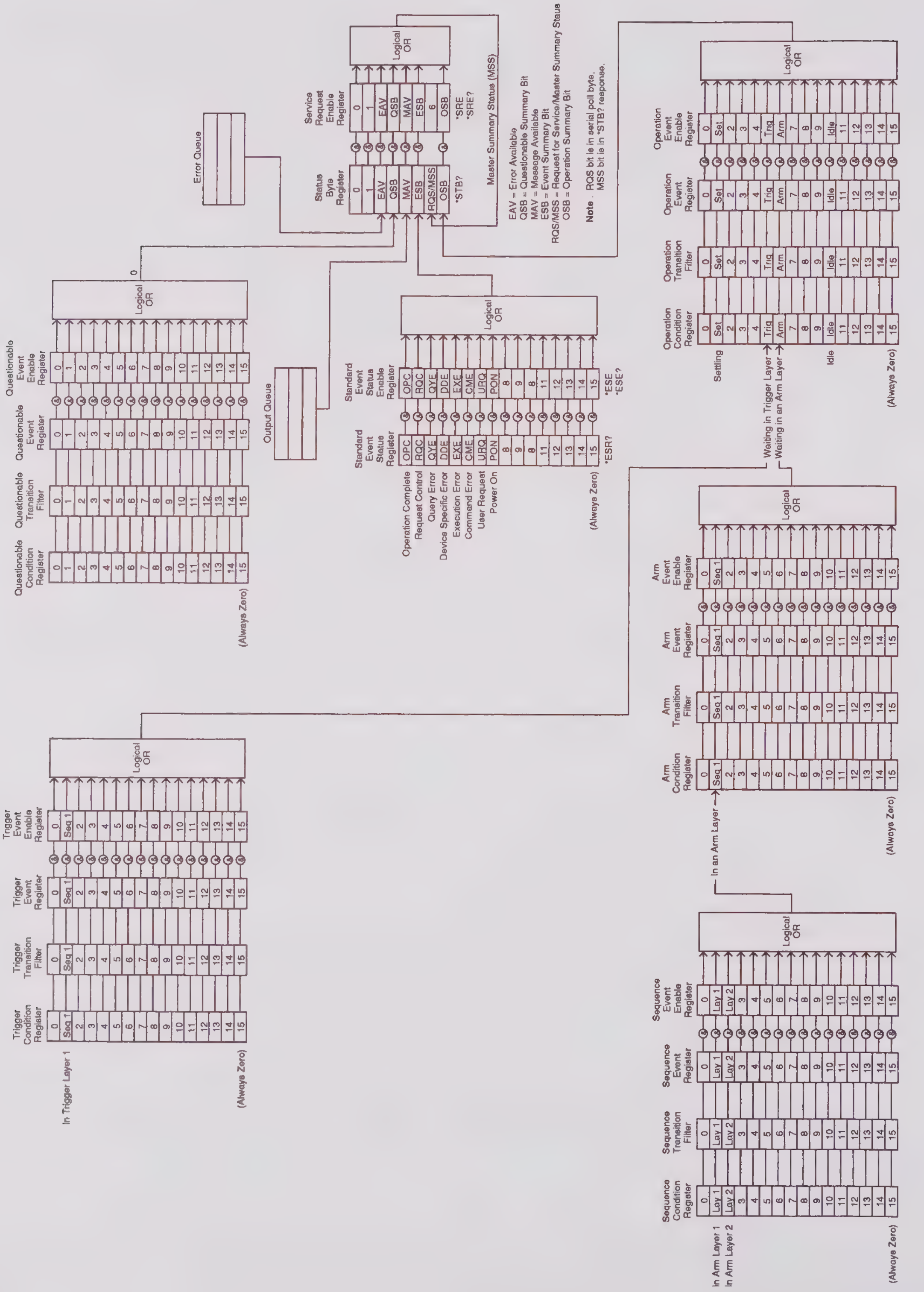
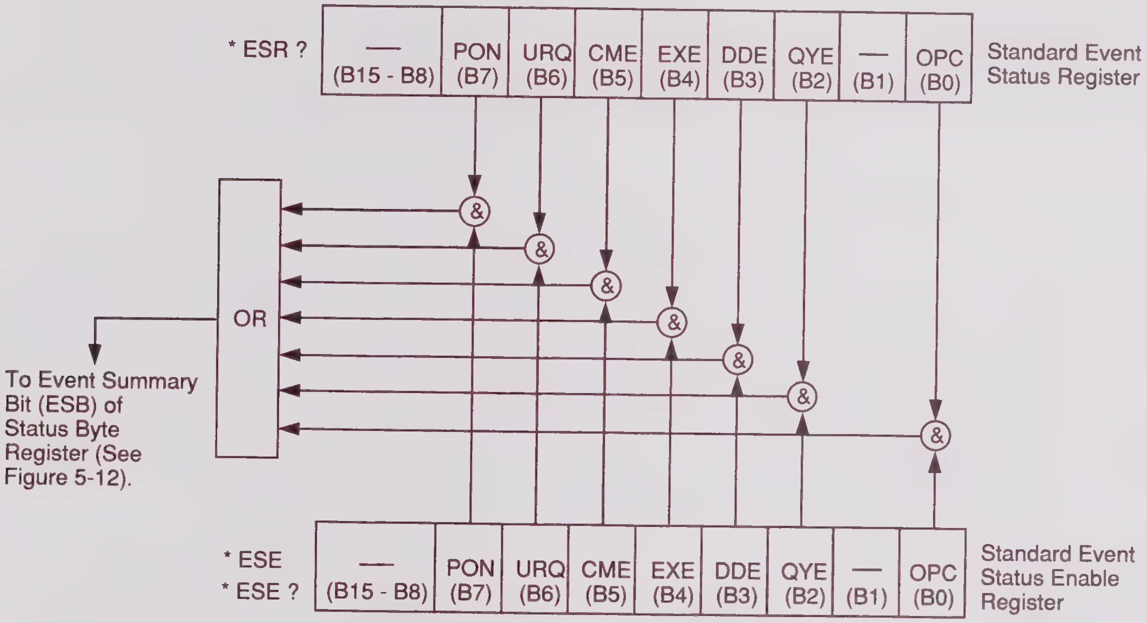

Error Queue
Output Queue
Status Byte Register
0
1
EAV
QSB
MAV
ESB
RQS/MSS
OSB
*STB?
Service Request Enable Register
6
*SRE
*SRE?
Logical OR
Master Summary Status (MSS)
EAV = Error Available
QSB = Questionable Summary Bit
MAV = Message Available
ESB = Event Summary Bit
RQS/MSS = Request for Service/Master Summary Staus
OSB = Operation Summary Bit
Note : RQS bit is in serial poll byte, MSS bit is in *STB? response.
Questionable Condition Register
Questionable Transition Filter
Questionable Event Register
Questionable Event Enable Register
(Always Zero)
Standard Event Status Register
Standard Event Status Enable Register
Operation Complete
Request Control
Query Error
Device Specific Error
Execution Error
Command Error
User Request
Power On
OPC
RQC
QYE
DDE
EXE
CME
URQ
PON
*ESR?
*ESE
*ESE?
Operation Condition Register
Operation Transition Filter
Operation Event Register
Operation Event Enable Register
Settling
Set
Waiting in Trigger Layer
Trig
Waiting in an Arm Layer
Arm
Idle
Trigger Condition Register
Trigger Transition Filter
Trigger Event Register
Trigger Event Enable Register
In Trigger Layer 1
Seq 1
Arm Condition Register
Arm Transition Filter
Arm Event Register
Arm Event Enable Register
In an Arm Layer
Sequence Condition Register
Sequence Transition Filter
Sequence Event Register
Sequence Event Enable Register
In Arm Layer 1
In Arm Layer 2
Lay 1
Lay 2
&

Figure 5-5
Model 7001 status register structure

5.6.1 Standard event status

The reporting of standard events is controlled by two 16-bit registers; the Standard Event Status Register and the Standard Event Status Enable Register. Figure 5-6 shows how these registers are structured.

In general, the occurrence of a standard event sets the appropriate bit in the Standard Event Status Register. This register can be read at any time to determine which, if any, standard events have occurred. Also, with the proper use of the Standard Event Status Enable Register, a standard event can set the Event Summary Bit (ESB) of the Status Byte Register. This allows the programmer to take advantage of the service request (SRQ) feature. See paragraph 5.6.8 for details.


* ESR ?
— (B15 - B8)
PON (B7)
URQ (B6)
CME (B5)
EXE (B4)
DDE (B3)
QYE (B2)
— (B1)
OPC (B0)
Standard Event Status Register
&
OR
To Event Summary Bit (ESB) of Status Byte Register (See Figure 5-12).
* ESE
* ESE ?
Standard Event Status Enable Register

PON = Power On
URQ = User Request
CME = Command Error
EXE = Execution Error
DDE = Device - Dependent Error
QYE = Query Error
OPC = Operation Complete

& = Logical AND
OR = Logical OR

Figure 5-6
Standard event status

Standard Event Status Register — This is a latched read only register that is used to record the occurrence of standard events. Each used bit in the register represents a standard event. Descriptions of these standard events are provided in paragraph 5.10.4.

When a standard event occurs, the appropriate bit in the Standard Event Status Register sets. For example, if you attempt to read data from an empty Output Queue, a Query Error (QYE) will occur and set bit B2 of the status register. A set bit in this register will remain set until an appropriate operation is performed to clear the register. The Standard Event Status Register can be read at any time by using the following common query command (see paragraph 5.10.4 for details):

```
*ESR?
```

Reading this register using the *ESR? command also clears the register. The following list summarizes all operations that clear the Standard Event Status Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the *ESR? common command.

Standard Event Status Enable Register — This register is programmed by the user and serves as a mask for standard events. When a standard event is masked, the occurrence of that event will not set the Event Summary Bit (ESB) in the Status Byte Register. Conversely, when a standard event is unmasked, the occurrence of that event will set the ESB bit.

A bit in the Standard Event Status Register is masked when the corresponding bit in the Standard Event Status Enable Register is cleared (0). When the masked bit of the Standard Event Status Register sets, it is ANDed with he corresponding cleared bit in the Standard Event Status Enable Register. The logic "0" output of the AND gate is applied to the input of the OR gate and thus, will not set the ESB bit in the Status Byte Register.

A bit in the Standard Event Status Register is unmasked when the corresponding bit in the Standard Event Status Enable Register is set (1). When the unmasked bit of the Standard Event Status Register sets, it is ANDed with the corresponding set bit in the Standard Event Status Enable Register. The logic "1" output of the AND gate is applied to the input of the OR gate and thus, sets the ESB bit in the Status Byte Register.

The individual bits of the Standard Event Status Enable Register can be set or cleared by using the following common command (see paragraph 5.10.2):

```
*ESE <NRf>
```

The Standard Event Status Enable register can be read at any time by using the following common query command (see paragraph 5.10.3 for details):

```
*ESE?
```

Reading this register using the *ESE? command does not clear the register. The following list summarizes all operations that will clear the Standard Event Status Enable Register:

1. Cycling power.
2. *ESE 0

5.6.2 Operation event status

The reporting of operation events is controlled by a set of 16-bit registers; the Operation Condition Register, the Transition Filter, the Operation Event Register, and the Operation Event Enable Register. Figure 5-7 shows how these registers are structured.

Notice in Figure 5-5 that bits B5 (Waiting in Trigger Layer) and B6 (Waiting in An Arm Layer) of the Operation Condition Register are controlled by the arm register set and the trigger set and the trigger register set (see paragraph 5.6.3 and 5.6.5 for details). Each of the bits that is used in these registers represents an operation event. Descriptions of the operation event bits are provided in paragraph 5.16.

The operation status registers are controlled by the :STATus :OPERation commands in the :STATus subsystem (see paragraph 5.16.

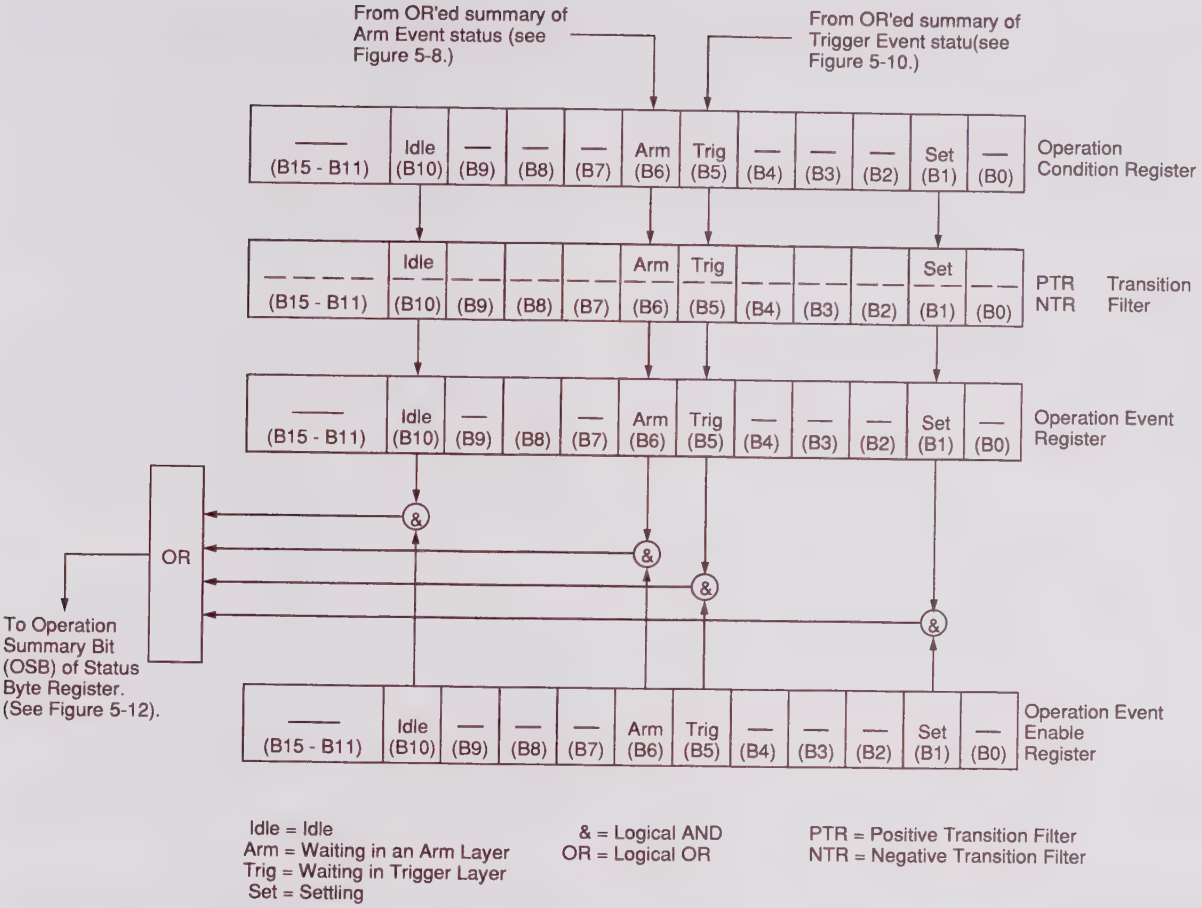

From OR'ed summary of Arm Event status (see Figure 5-8.)
From OR'ed summary of Trigger Event statu(see Figure 5-10.)
(B15 - B11)
Idle (B10)
(B9)
(B8)
(B7)
Arm (B6)
Trig (B5)
(B4)
(B3)
(B2)
Set (B1)
(B0)
Operation Condition Register
PTR NTR
Transition Filter
Operation Event Register
OR
&
To Operation Summary Bit (OSB) of Status Byte Register. (See Figure 5-12).
Operation Event Enable Register
Idle = Idle
Arm = Waiting in an Arm Layer
Trig = Waiting in Trigger Layer
Set = Settling
& = Logical AND
OR = Logical OR
PTR = Positive Transition Filter
NTR = Negative Transition Filter

Figure 5-7
Operation event status

Operation Condition Register — This is a real-time 16-bit read-only register that constantly updates to reflect the current operating conditions of the Model 7001. For example, when the instrument is in idle, bit B10 (Idle) of this register will be set. When the instrument leaves the idle state, bit B10 will clear.

The following SCPI query command can be used to read the Operation Condition Register:

```
:STATus:OPERation:CONDition?
```

The Operation Condition Register and the Transition Filter are used to set the bits of the Operation Event Register. The Transition Filter is discussed next.

Operation Transition Filter — The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) in the Operation Condition Register will set the corresponding bit in the Operation Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR) or both. When an event bit is programmed for a positive transition, the event bit in the Operation Event Register will set when the corresponding bit in the Operation Event Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0.

The individual bits of the transition filter registers can be set or cleared by using the following SCPI commands:

```
:STATus:OPERation:PTR <NRf>
:STATus:OPERation:NTR <NRf>
```

The transition filter registers can be read at any time by using the following SCPI query commands:

```
:STATus:OPERATION:PTR?
:STATus:OPERation:NTR?
```

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and clear (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:PTR 65535 and :STATus:OPERation:NTR 0 commands.

Operation Event Register — This is a latched, read-only register whose bits are set by the Operation Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing operation. The bits of this register are logically ANDed with the bits of the Operation Event Enable Register and applied to an OR gate. The output of the OR gate is the Operation Summary Bit (OSB) that is applied to the Status Byte Register. The following SCPI query command can be used to read the Operation Event Register:

```
:STATus:OPERation?
```

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Operation Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:OPERation:EVENt? query command.

Operation Event Enable Register — This register is programmed by the user and serves as a mask for the Operation Event Register. When masked, a set bit in the Operation Event Register will not set the Operation Summary Bit (OSB) in the Status Byte Register. Conversely, when unmasked, a set bit in the Operation Event Register will set the OSB bit.

A bit in the Operation Event Register is masked when the corresponding bit in the Operation Event Enable Register is cleared (0). When the masked bit of the Operation Event Register sets, it is ANDed with the corresponding cleared bit in the Operation Event Enable Register. The logic “0” output of the AND gate is applied to the input of the OR gate and thus, will not set the OSB bit in the Status Byte Register.

A bit in the Operation Event Register is unmasked when the corresponding bit in the Operation Event Enable Register is set (1). When the unmasked bit of the Operation Event Register sets, it is ANDed with the corresponding set bit in the Operation Event Enable Register. The logic “1” output of the AND gate is applied to the input of the OR gate and thus, will set the OSB bit in the Status Byte Register.

The individual bits of the Operation Event Enable Register can be set or cleared by using the following SCPI command:

```
:STATus:OPERation:ENABle <NRf>
```

The following SCPI query command can be used to read the Operation Event Enable Register:

```
:STATus:OPERation:ENABle?
```

Reading this register using the above SCPI command does not clear the register. The following list summarizes operations that will clear the Operation Event Enable Register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:ENABle 0 command.

5.6.3 Arm event status

The reporting of the arm event is controlled by a set of 16-bit registers; the Arm Condition Register, the Transition Filter, Arm Event Register, and the Arm Event Enable Register. Figure 5-8 shows how these registers are structured. Notice in Figure 5-5 that bit B1 (In An Arm Layer) of the Arm Condition Register is controlled by the sequence event register set (see paragraph 5.6.4 for details). In general, bit B1 sets when the instrument is in the arm layer (Arm Layer 1) or scan layer (Arm Layer 2) of operation. An explanation of the operation process over the bus is provided in paragraph 5.7.

The various registers used for arm event status are described as follows: Note that these registers are controlled by the :STATus:OPERation:ARM commands of the :STATus subsystem (see paragraph 5.16).

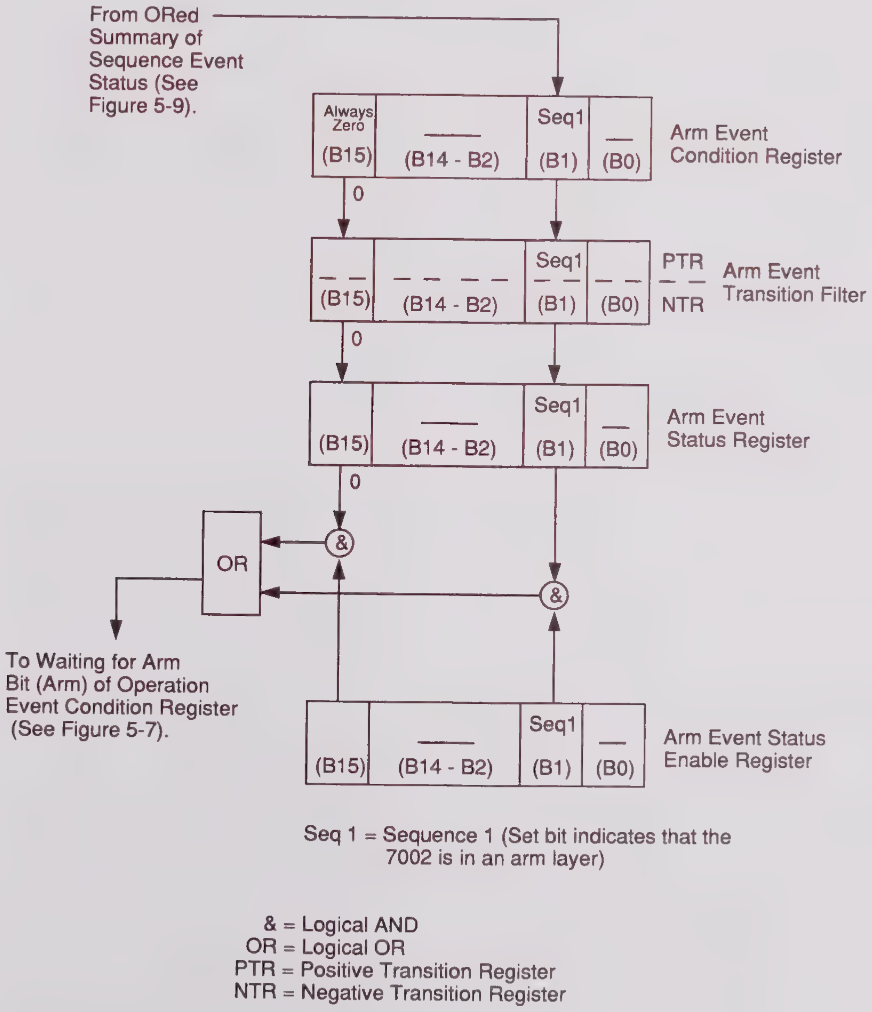

From ORed Summary of Sequence Event Status (See Figure 5-9).
Always Zero
(B15)
(B14 - B2)
Seq1
(B1)
(B0)
Arm Event Condition Register
0
PTR
NTR
Arm Event Transition Filter
Arm Event Status Register
OR
&
To Waiting for Arm Bit (Arm) of Operation Event Condition Register (See Figure 5-7).
Arm Event Status Enable Register
Seq 1 = Sequence 1 (Set bit indicates that the 7002 is in an arm layer)
& = Logical AND
OR = Logical OR
PTR = Positive Transition Register
NTR = Negative Transition Register

Figure 5-8
Arm event status

Arm Condition Register — This is a real-time 16-bit read-only register that constantly updates to reflect the ORed summary of the sequence event register set. In general, if bit B1 is set, the instrument is in an arm layer. The following SCPI query command can be used to read the Arm Condition Register:

```
:STATus:OPERation:ARM:CONDition?
```

The Arm Condition Register and the Transition Filter are used to set the bits of the Arm Event Register. The Transition Filter is discussed next.

Arm Transition Filter — The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) of bit B1 in the Arm Condition Register will set bit B1 in the Arm Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR) or both. When an event bit is programmed for a positive transition, the event bit in the Arm Event Register will set when the corresponding bit in the Arm Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0. The transition filter registers can be set or cleared by using the following SCPI commands:

```
:STATus:OPERation:ARM:PTR <NRf>
:STATus:OPERation:ARM:NTR <NRf>
```

The transition filter registers can be read at any time by using the following SCPI query commands:

```
:STATus:OPERation:ARM:PTR?
:STATus:OPERation:ARM:NTR?
```

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and reset (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:ARM:PTR 65535 and :STATus:OPERation:ARM:NTR 0 commands.

Arm Event Register — This is a latched, read-only register whose bits are set by the Arm Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing operation. The bits of this register are logically ANDed with the bits of the Arm Event Enable Register and applied to an OR gate. The output of the OR gate is the Arm Summary Bit that is applied to the Operation Condition Register. The following SCPI query command can be used to read the Arm Event Register:

```
:STATus:OPERation:ARM:EVENt?
```

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Operation Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:OPERation:ARM? query command.

Arm Event Enable Register — This register is programmed by the user and serves as a mask for the Arm Event Register. When masked, a set bit (B1) in the Arm Event Register will not set the Waiting for Arm bit in the Operation Condition Register. Conversely, when unmasked, a set bit (b1) in the Arm Event Register will set the Waiting for Arm bit.

Bit B1 in the Arm Event Register is masked when the corresponding bit (B1) in the Arm Event Enable Register is cleared (0). When the masked bit of the Arm Event Register sets, it is ANDed with the corresponding cleared bit in the Arm Event Enable Register. The logic "0" output of the AND gate is applied to the input of the OR gate and thus, will not set the Waiting for Arm bit in the Operation Condition Register.

Bit B1 in the Arm Event Register is unmasked when the corresponding bit (B1) in the Arm Event Enable Register is set

(1). When the unmasked bit of the Arm Event Register sets, it is ANDed with the corresponding set bit in the Arm Event Enable Register. The logic "1" output of the AND gate is applied to the input or the OR gate and thus, will set the Waiting for Arm bit in the Operation Condition Register.

Bit B1 of the Arm Event Enable Register can be set or cleared by using the following SCPI command:

```
:STATus:OPERation:ARM:ENABle <NRf>
```

The following SCPI query command can be used to read the Arm Event Enable Register:

```
:STATus:OPERation:ARM:ENABle?
```

Reading this register using the above SCPI command will not clear the register. The following list summarizes operations that will clear the Arm Event Enable Register:

1. Cycling power.
2. Sending the :STATus:OPERation:ARM:ENABle 0 command.

5.6.4 Sequence event status

The reporting of sequence events is controlled by a set of 16-bit registers; the Sequence Condition Register, the Transition Filter, the Sequence Event Register and the Sequence Event Enable Register. Figure 5-9 shows how these registers are structured.

Two bits of this register set are used by the Model 7001 to report sequence events. Bit B1 (In Arm Layer 1) is set when instrument is in (or exited) the arm layer (Arm Layer 1) of operation. Bit B2 (In Arm Layer 2) is set when the instrument is in (or exited) the scan layer (Arm Layer 2). The operation process over the bus is explained in paragraph 5.7.

The various registers used for sequence event status are described as follows. Note that these registers are controlled by the :STATus:OPERation:ARM:SEQuence commands of the :STATus subsystem (see paragraph 5.16).

Sequence Condition Register — This is a real-time 16-bit read-only register that constantly updates to reflect the current arm layer status of the instrument. For example, if the Model 7001 is currently in the scan layer of operation, bit B2 (In Arm Layer 2) of this register will be set.

The following SCPI query command can be used to read the Sequence Condition Register:

```
:STATus:OPERation:ARM:SEQuence:CONDition?
```

The Sequence Condition Register and the Transition Filter are used to set the bits of the Sequence Event Register. The Transition Filter is discussed next.

Sequence Transition Filter — The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) in the Sequence Condition Register will set the corresponding bit in the Sequence Event Register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR) or both. When an event bit is programmed for a positive transition, the event bit in the Sequence Event Register will set when the corresponding bit in the Sequence Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0.

The transition filter registers can be set or cleared by using the following SCPI commands:

```
:STATus:OPERation:ARM:SEQuence:PTRansition <NRf>
:STATus:OPERation:ARM:SEQuence:NTRansition <NRf>
```

The transition filter registers can be read at any time by using the following SCPI query commands:

```
:STATus:OPERation:ARM:SEQuence:PTRansition?
:STATus:OPERation:ARM:SEQuence:NTRansition?
```

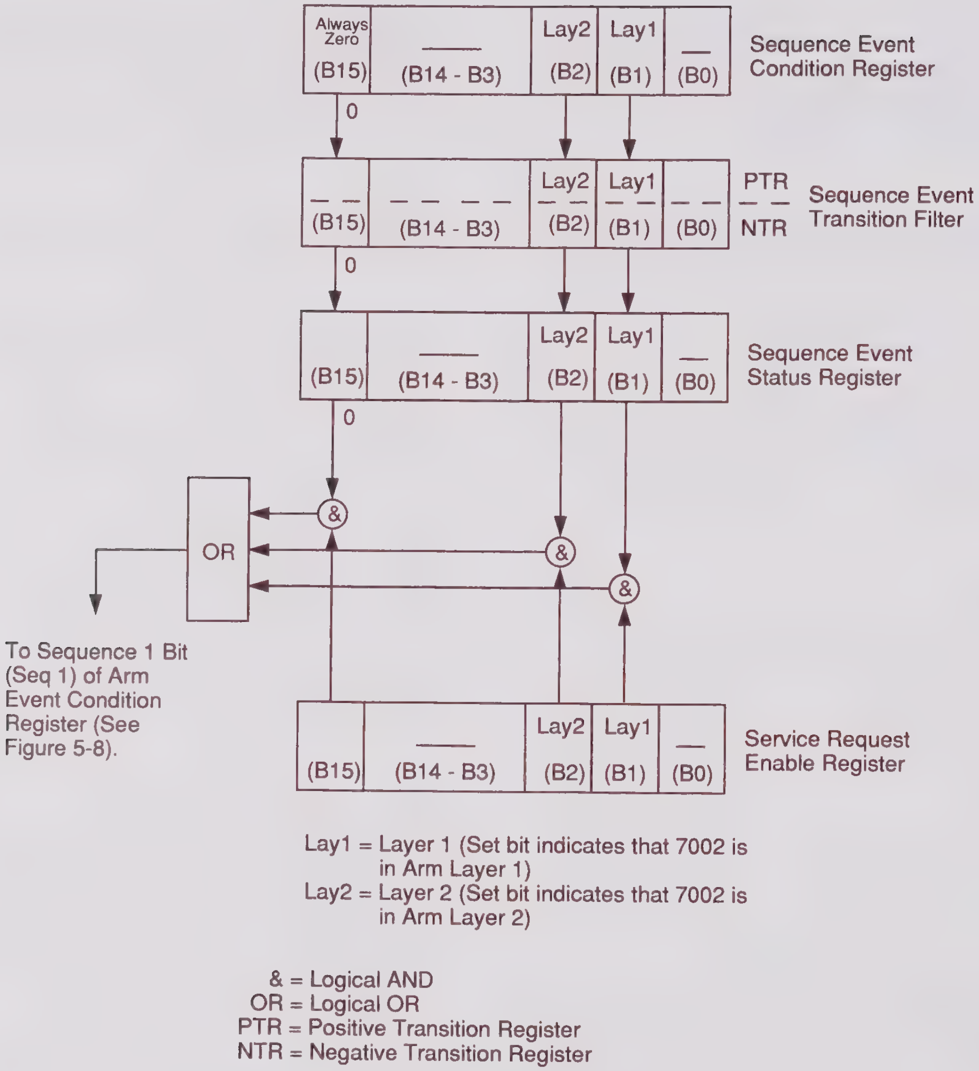

Always Zero
(B15)
(B14 - B3)
Lay2
(B2)
Lay1
(B1)
(B0)
Sequence Event Condition Register
0
(B15)
(B14 - B3)
Lay2
(B2)
Lay1
(B1)
(B0)
PTR
NTR
Sequence Event Transition Filter
0
(B15)
(B14 - B3)
Lay2
(B2)
Lay1
(B1)
(B0)
Sequence Event Status Register
0
&
OR
&
&
To Sequence 1 Bit (Seq 1) of Arm Event Condition Register (See Figure 5-8).
(B15)
(B14 - B3)
Lay2
(B2)
Lay1
(B1)
(B0)
Service Request Enable Register
Lay1 = Layer 1 (Set bit indicates that 7002 is in Arm Layer 1)
Lay2 = Layer 2 (Set bit indicates that 7002 is in Arm Layer 2)
& = Logical AND
OR = Logical OR
PTR = Positive Transition Register
NTR = Negative Transition Register

Figure 5-9
Sequence event status

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and reset (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:ARM:SEQuence:PTR 65535 and :STATus:OPERation:ARM:SEQuence:NTR 0 commands.

Sequence Event Register — This is a latched, read-only register whose bits are set by the Sequence Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing sequence. The bits of this register are logically

ANDed with the bits of the Sequence Event Enable Register and applied to an OR gate. The output of the OR gate is applied to bit B1 of the Arm Condition Register (see paragraph 5.6.3). The following SCPI query command can be used to read the Sequence Event Register:

:STATus:OPERation:ARM:SEQuence?

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Sequence Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:OPERation:ARM:SEQuence? query command.

Sequence Event Enable Register — This register is programmed by the user and serves as a mask for the Sequence Event Register. When masked, a set bit in the Sequence Event Register will not set bit B1 of the Arm Condition Register. Conversely, when unmasked, a set bit in the Sequence Event Register will set the bit B1 of the Arm Condition Register.

A bit in the Sequence Event Register is masked when the corresponding bit in the Sequence Event Enable Register is cleared (0). When the masked bit of the Sequence Event Register sets, it is ANDed with the corresponding cleared bit in the Sequence Event Enable Register. The logic "0" output of the AND gate is applied to the input of the OR gate and thus, will not set bit B1 of the Arm Condition Register.

A bit in the Sequence Event Register is unmasked when the corresponding bit in the Sequence Event Enable Register is set (1). When the unmasked bit of the Sequence Event Register sets, it is ANDed with the corresponding set bit in the Sequence Event Enable Register. The logic "1" output of the AND gate is applied to the input of the OR gate and thus, will set bit B1 of the Arm Condition Register.

The individual bits of the Sequence Event Enable Register can be set or cleared by using the following SCPI command:

:STATus:OPERation:ARM:SEQuence:ENABle <NRf>

The following SCPI query command can be used to read the Sequence Event Enable Register:

:STATus:OPERation:ARM:SEQuence:ENABle?

Reading this register using the above SCPI command will not clear the register. The following list summarizes operations that will clear the Sequence Event Enable Register:

1. Cycling power.
2. Sending the :STATus:OPERation:ARM:SEQuence:ENABle 0 command.

5.6.5 Trigger event status

The reporting of the trigger event is controlled by a set of 16-bit registers; the Trigger Condition Register, the Transition Filter, the Trigger Event Register, and the Trigger Event Enable Register. Figure 5-10 shows how these registers are structured.

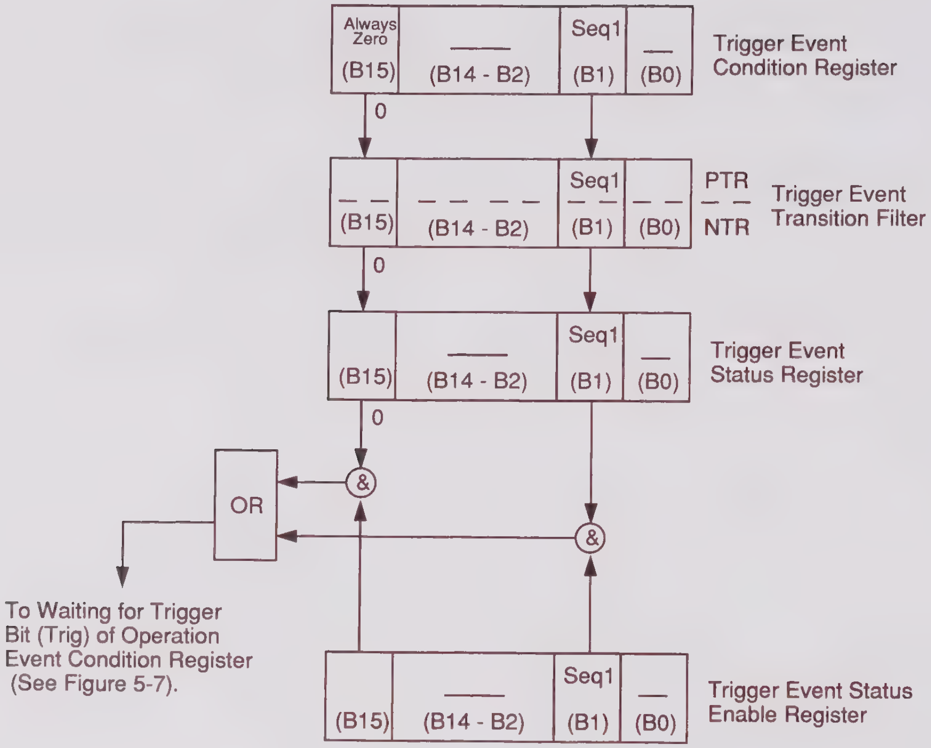
Bit B1 (Seq1) of the register set is used for the trigger event (In Trigger Layer). In general, Bit B1 sets when the instrument is in (or has exited) the measure layer of operation. An explanation of the Model 7001 operation process is provided in paragraph 5.7. The various registers used for trigger event status are described as follows: Note that these registers are controlled by the :STATus:OPERation:TRIGger commands of the :STATus subsystem (see paragraph 5.16).

Trigger Condition Register — This is a real-time 16-bit read-only register that constantly updates to reflect the trigger layer status of the instrument. If bit B1 is set, the instrument is in the trigger layer (measure layer) of operation.

The following SCPI query command can be used to read the Trigger Condition Register:

:STATus:OPERation:TRIGger:CONDition?

The Trigger Condition Register and the Transition Filter are used to set bit B1 of the Trigger Event Register. The Transition Filter is discussed next.


Always Zero
(B15)
(B14 - B2)
Seq1
(B1)
(B0)
Trigger Event Condition Register
0
PTR
NTR
Trigger Event Transition Filter
Trigger Event Status Register
OR
&
To Waiting for Trigger Bit (Trig) of Operation Event Condition Register (See Figure 5-7).
Trigger Event Status Enable Register

Seq 1 = Sequence 1 (Set bit indicates that the 7002 is in the Trigger Layer)

& = Logical AND
OR = Logical OR
PTR = Positive Transition Register
NTR = Negative Transition Register

Figure 5-10
Trigger event status

Trigger Event Transition Filter — The transition filter is made up of two 16-bit registers that are programmed by the user. It is used to specify which transition (0 to 1, or 1 to 0) of bit B1 in the Trigger Condition Register will set bit B1 in the Trigger Event register.

The filter can be programmed for positive transitions (PTR), negative transitions (NTR) or both. When an event bit is programmed for a positive transition, the event bit in the Trigger Event Register will set when the corresponding bit in the Trigger Condition Register changes from 0 to 1. Conversely, when programmed for a negative transition, the bit in the status register will set when the corresponding bit in the condition register changes from 1 to 0.

The transition filter registers can be set or cleared by using the following SCPI commands:

```
:STATus:OPERation:TRIGger:PTRansition <NRf>
:STATus:OPERation:TRIGger:NTRanstion <NRf>
```

The transition filter register can be read at any time by using the following SCPI query commands:

:STATus:OPERation:TRIGger:PTRansition?
:STATus:OPERation:TRIGger:NTRansition?

Reading a transition filter register using the above query commands does not affect the contents of the register.

The following operations will set (1) all the bits of the PTR register and reset (0) all the bits of the NTR register:

1. Cycling power.
2. Sending the :STATus:PRESet command.
3. Sending the :STATus:OPERation:TRIGger:NTR 0 commands.

Trigger Event Register — This is a latched, read-only register whose bits are set by the Trigger Condition Register and Transition Filter. Once a bit in this register is set, it will remain set (latched) until the register is cleared by a specific clearing operation. The bits of this register are logically ANDed with the bits of the Trigger Event Enable Register and applied to an OR gate. The output of the OR gate is applied to bit B5 (Waiting for Trigger) of the Operation Condition Register.

The following SCPI query command can be used to read the Trigger Event Register:

:STATus:OPERation:TRIGger:EVENt?

Reading this register using the above SCPI command clears the register. The following list summarizes all operations that will clear the Trigger Event Register:

1. Cycling power.
2. Sending the *CLS common command.
3. Sending the :STATus:OPERation:TRIGger? query command.

Trigger Event Enable Register — This register is programmed by the user and serves as a mask for the Trigger Event Register. When masked, a set bit (B1) in the Trigger Event Register cannot set bit B5 (Waiting for Trigger) of the Operation Condition Register. Conversely, when unmasked, a set bit (B1) in the Trigger Event Register will set bit B5 of the Operation Condition Register.

Bit B1 in the Trigger Event Enable Register is masked when the corresponding bit (B1) in the Trigger Event Enable Register is cleared (0). When the masked bit of the Trigger Event Register sets, it is ANDed with the corresponding cleared bit in the Trigger Event Enable Register. The logic “0” output of the AND gate is applied to the input of the OR gate and thus, cannot set bit B5 of the Operation Condition Register.

Bit B1 in the Trigger Event Register is unmasked when the corresponding bit (B1) in the Trigger Event Enable Register is set (1). When the unmasked bit of the Trigger Event Register sets, it is ANDed with the corresponding set bit in the Trigger Event Enable Register. The logic “1” output of the AND gate is applied to the input of the OR gate and thus, will set bit B5 of the Operation Condition Register.

Bit B1 of the Trigger Event Enable Register can be set or cleared by using the following SCPI command:

:STATus:OPERation:TRIGger:ENABle <NRf>

The following SCPI query command can be used to read the Trigger Event Enable Register:

:STATus:OPERation:TRIGger:ENABle?

Reading this register using the above SCPI command will not clear the register. The following list summarizes operations that will clear the Trigger Event Enable Register:

1. Cycling power.
2. Sending the :STATus:OPERation:TRIGger:ENABle 0 command.

5.6.6 Questionable event status

The Model 7001 does not implement questionable events. Thus, the QSB summary bit is always zero as shown in Figure 5-5. Even though they are not used, the questionable event registers are part of the status structure as required by SCPI.

5.6.7 Queues

The Model 7001 uses two queues; the Output Queue and the Error/Status Queue. The queues are first-in first-out (FIFO) registers. They are used to hold data messages and error/status messages respectively. The Model 7001 Status Model (Figure 5-5) shows how the two queues are structured with the other registers.

Output Queue — The Output Queue is used to hold all data that pertains to the normal operation of the instrument. For example, when a query command is sent, the data message that pertains to that query is placed in the Output Queue.

When a data message is placed in the Output Queue, the Message Available (MAV) bit in the Status Byte Register becomes set. A data message is cleared from the Output Queue when it is read. The Output Queue is considered cleared when it is empty. An empty Output Queue clears the MAV bit in the Status Byte Register.

A message from the Output Queue is read by addressing the Model 7001 to talk. The following programming example in HP BASIC 4.0 sends a query command, sends the data message to the computer, and then displays it on the CRT.

```
10  OUTPUT 707; "*IDN?"    ! Request identification
                             code
20  ENTER 707; A$          ! Address 7001 to talk
30  PRINT A$               ! Display ID code
40  END
```

Error Queue — The Error Queue is used to hold error messages and status messages. When an error or status event occurs, a message that defines the error/status is placed in the Error Queue. This queue will hold up to 10 messages.

When a message is placed in the Error Queue, the Error Available (EAV) bit in the Status Byte Register is set. An error message is cleared from the Error Queue when it is read. The Error Queue is considered cleared when it is empty. An empty Error Queue clears the EAV bit in the Status Byte Register.

An error message from the Error Queue is read by sending either of the following SCPI query commands and then addressing the Model 7001 to talk:

```
:SYSTem:ERRor?
:STATus:QUEue?
```

Refer to paragraphs 5.16.7 (:STATus:QUEue?) and 5.17.4 (:SYSTem:ERRor?) for complete information on reading error messages.

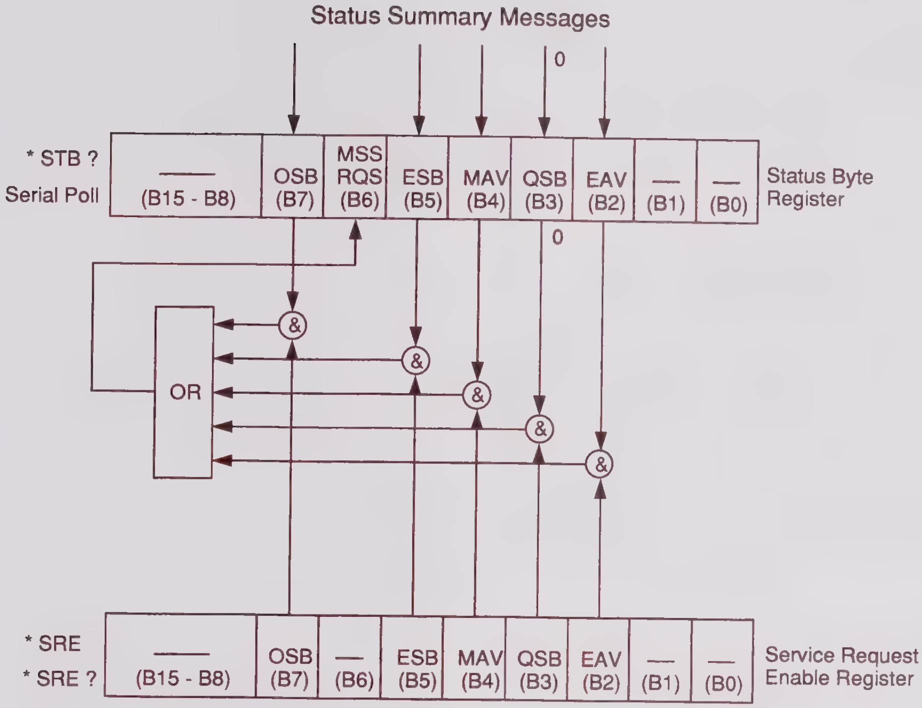
5.6.8 Status byte and service request (SRQ)

Service request is controlled by two 8-bit registers; the Status Byte Register and the Service Request Enable Register. The structure of these registers is shown in Figure 5-11.

Status Byte Register — The summary messages from the status registers and queues are used to set or clear the appropriate bits (B2, B3, B4, B5 and B7) of the Status Byte Register. These bits do not latch and their states (0 or 1) are solely dependent on the summary messages (0 or 1). For example, if the Standard Event Status Register is read, its register will clear. As a result, its summary message will reset to 0, which in turn will clear the ESB bit in the Status Byte Register.

Bit B6 in the Status Byte Register is either:

- The Master Summary Status (MSB) bit, sent in response to the *STB? command, indicates the status of any set bits with corresponding enable bits set.
- The Request for Service (RQS) bit, sent in response to a serial poll, indicates which device was requesting service by pulling on the SRQ line.


Status Summary Messages
0
* STB ?
Serial Poll
(B15 - B8)
OSB (B7)
MSS RQS (B6)
ESB (B5)
MAV (B4)
QSB (B3)
EAV (B2)
(B1)
(B0)
Status Byte Register
0
&
OR
* SRE
* SRE ?
(B15 - B8)
OSB (B7)
(B6)
ESB (B5)
MAV (B4)
QSB (B3)
EAV (B2)
(B1)
(B0)
Service Request Enable Register

OSB = Operation Summary Bit
MSS = Master Summary Status (IEEE-488.2)
RQS = Request for Service (IEEE-488.1)
ESB = Event Summary Bit
MAV = Message Available
QSB = Questionable Summary Bit
EAV = Error Available

& = Logical AND
OR = Logical OR

Figure 5-11
Status byte and service request (SRQ)

For description of the other bits in the Status Byte Register, refer to paragraph 5.10.14.

The IEEE-488.2 standard uses the following common query command that simply reads the Status Byte Register contents:

*STB?

When reading the Status Byte Register using the *STB? command, bit B6 is called the MSB bit. None of the bits in the Status Byte Register are cleared when using the *STB? command to read it.

The IEEE-488.1 standard has a serial poll sequence that will also read the Status Byte Register and is better suited to detect a service request (SRQ). When using the serial poll, bit B6 is called the RQS bit. Serial polling causes bit B6 (RQS) to reset. Serial polling is discussed in more detail later in this paragraph (see "Serial Poll and SRQ").

The following operations clears all bits of the Status Byte Register:

1. Cycling power.
2. Sending the *CLS common command.

NOTE

The MAV bit may or may not be cleared.

Service Request Enable Register — This register is programmed by the user and serves as a mask for the Status Summary Message bits (B2, B3, B4, B5 and B7) of the Status Byte Register. When masked, a set summary bit in the Status Byte Register will not set bit B6 (MSS/RQS) of the Status Byte Register. Conversely, when unmasked, a set summary bit in the Status Byte Register will set bit B6.

A Status Summary Message bit in the Status Byte Register is masked when the corresponding bit in the Service Request Enable Register is cleared (0). When the masked summary bit in the Status Byte Register sets, it is ANDed with the corresponding cleared bit in the Service Request Enable Register. The logic "0" output of the AND gate is applied to the input of the OR gate and thus, will not set the MSS/RQS bit in the Status Byte Register.

A Status Summary Message bit in the Status Byte Register is unmasked when the corresponding bit in the Service Request Enable Register is set (1). When the unmasked summary bit in the Status Byte Register sets, it is ANDed with the corresponding set bit in the Service Request Enable Register. The logic "1" output of the AND gate is applied to the input of the OR gate and thus, will set the MSS/RQS bit in the Status Byte Register.

The individual bits of the Service Request Enable Register can be set or cleared by using the following common command (see paragraph 5.10.12 for details):

*SRE <NRf>

The Service Request Enable Register can be read using the following common query command (see paragraph 5.10.13 for details):

*SRE?

The Service Request Enable Register is not cleared when it is read using the *SRE? query command. The Service Request Enable Register will clear when power is cycled or a parameter (n) value of zero is sent with the *SRE command (*SRE 0).

Serial poll and SRQ

Any enabled event summary bit that goes from 0 to 1 will set RQS and generate a service request (SRQ). The user's test program can periodically read the Status Byte Register to check to see if a service request (SRQ) has occurred and what caused it. In the event of an SRQ, the program can, for example, branch to an appropriate subroutine that will service the request. Typically, service requests (SRQs) are managed by the serial poll sequence of the Model 7001. If an SRQ does not occur, bit B6 (RQS) of the Status Byte Register will remain cleared and the program will simply proceed normally after the serial poll is performed. If an SRQ does occur, bit B6 of the Status Byte Register will set and the program can branch to a service subroutine when the SRQ is detected by the serial poll.

The serial poll will automatically reset RQS of the Status Byte Register. This will allow subsequent serial polls to monitor Bit 6 for an SRQ occurrence generated by other event types. After a serial poll, the same event can cause another SRQ, even if the event register which caused the first SRQ has not been cleared.

A serial poll clears RQS but does not clear MSS. The MSS bit will stay set until all Status Byte event summary bits are cleared or until the corresponding bits in the service request enable registers are cleared.

The following HP BASIC 4.0 programming example demonstrates how serial poll can be used to detect an SRQ.

```
10   REMOTE 707
20   CLEAR 707
30   OUTPUT 707;”*ESE 32”     ! Unmask command er-
                                ror bit (B5) in Stan-
                                dard Event Enable
                                Register.
```

```
40  OUTPUT 707;"*SRE 32"        ! Unmask event sum-
                                  mary bit (B5) in Ser-
                                  vice Request Enable
                                  Register.
50  OUTPUT 707;"*ESE"           ! Program command er-
                                  ror (missing parame-
                                  ter) to generate SRQ.
60  WAIT 1
70  S=SPOLL (707)               ! Serial poll 7001.
80  IF BIT (S,6) THEN Service   ! Go to Service (line
                                  200).
90  END
200 SUB Service
210 PRINT "B7 B6 B5 B4 B3       ! Identify bits.
    B2 B1 B0"
220 FOR I=7 TO 0 STEP -1        ! Loop eight times.
230 PRINT BIT (S,I)             ! Display bit values
240 NEXT I
250 SUBEND
```

Program analysis:

Line 10	Place 7001 in remote.
Line 20	Perform a device clear.
Line 30	Set bit B5 of Standard Event Enable Register. This unmasks the command error event.
Line 40	Set bit B5 of the Service Request Enable Register. This unmasks the event summary message.
Line 50	Send an illegal command in order to generate an SRQ.
Line 60	Wait for a second to ensure completion of command execution.
Line 70	If SRQ occurred, bit B6 in Status Byte Register will be set and program will go to Service subroutine.
Line 200 to 240	Service subroutine displays the bit values (0 or 1) of the Status Byte Register. For this example, bit B5 (ESB) and bit B6 (RQS) will be set.

The actual serial poll sequence is explained in paragraph 5.8.8.

5.7 Trigger Model (IEEE-488 operation)

The following information describes the operation process of the Model 7001 over the IEEE-488 bus. The flowchart in Figure 5-12, which summarizes operation over the bus, is called the Trigger Model. It is called the Trigger Model because operation is controlled by SCPI commands from the Trigger subsystem (see paragraph 5.18). Notice that key SCPI commands are included in the Trigger Model.

Idle and initiate

The instrument is considered to be in the idle state whenever it is not operating within one of the layers of the Trigger Model. The front panel ARM indicator is off when the instrument is in the idle state. While in the idle state, the instrument cannot perform any scan functions. Over the bus, there are two SCPI commands that can be used to take the instrument out of the idle state; :INITiate or :INITiate:CONTinuous ON.

Notice that with continuous initiation enabled (:INIT:CONT ON), the instrument will not remain in the idle state after all programmed operations are completed. However, the instrument can be returned to the idle state at any time by sending the *RST command, or the :SYST:PRES command.

Once the instrument is taken out of the idle state, operation proceeds into the arm layer (Arm Layer 1) of the Trigger Model.

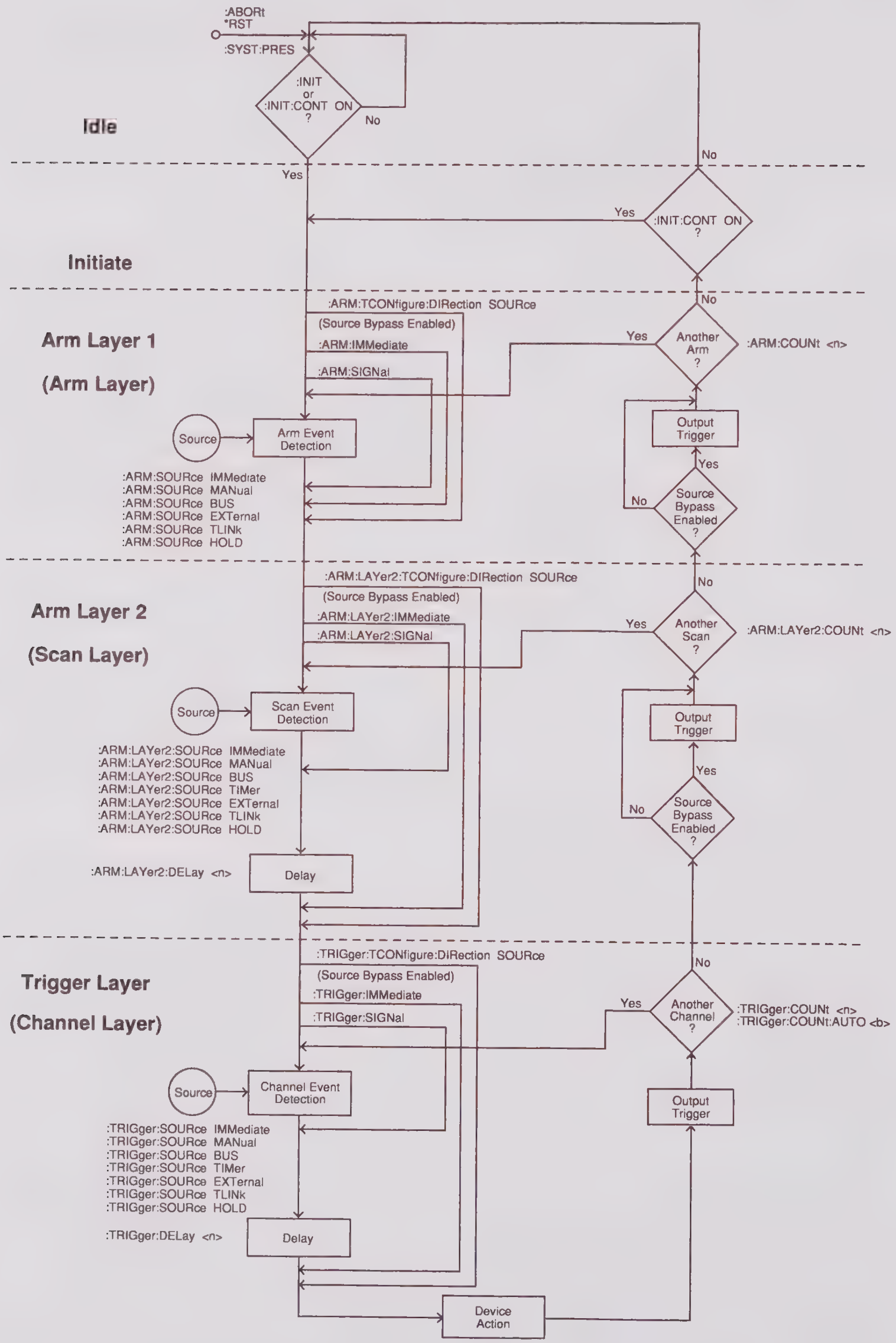

:ABORt
*RST
:SYST:PRES
:INIT or :INIT:CONT ON ?
No
Idle
No
Yes
Yes
:INIT:CONT ON ?
Initiate
No
:ARM:TCONfigure:DIRection SOURce
(Source Bypass Enabled)
:ARM:IMMediate
:ARM:SIGNal
Yes
Another Arm ?
:ARM:COUNt <n>
Arm Layer 1
(Arm Layer)
Source
Arm Event Detection
Output Trigger
Yes
No
Source Bypass Enabled ?
:ARM:SOURce IMMediate
:ARM:SOURce MANual
:ARM:SOURce BUS
:ARM:SOURce EXTernal
:ARM:SOURce TLINk
:ARM:SOURce HOLD
:ARM:LAYer2:TCONfigure:DIRection SOURce
No
(Source Bypass Enabled)
:ARM:LAYer2:IMMediate
:ARM:LAYer2:SIGNal
Yes
Another Scan ?
:ARM:LAYer2:COUNt <n>
Arm Layer 2
(Scan Layer)
Source
Scan Event Detection
Output Trigger
Yes
No
Source Bypass Enabled ?
:ARM:LAYer2:SOURce IMMediate
:ARM:LAYer2:SOURce MANual
:ARM:LAYer2:SOURce BUS
:ARM:LAYer2:SOURce TIMer
:ARM:LAYer2:SOURce EXTernal
:ARM:LAYer2:SOURce TLINk
:ARM:LAYer2:SOURce HOLD
:ARM:LAYer2:DELay <n>
Delay
:TRIGger:TCONfigure:DIRection SOURce
No
(Source Bypass Enabled)
:TRIGger:IMMediate
:TRIGger:SIGNal
Yes
Another Channel ?
:TRIGger:COUNt <n>
:TRIGger:COUNt:AUTO <b>
Trigger Layer
(Channel Layer)
Source
Channel Event Detection
Output Trigger
:TRIGger:SOURce IMMediate
:TRIGger:SOURce MANual
:TRIGger:SOURce BUS
:TRIGger:SOURce TIMer
:TRIGger:SOURce EXTernal
:TRIGger:SOURce TLINk
:TRIGger:SOURce HOLD
:TRIGger:DELay <n>
Delay
Device Action

Figure 5-12
Trigger Model (IEEE-488 bus operation)

Arm layer1

NOTE

For front panel operation, this layer is called the arm layer.

In general, the instrument requires an arm event to allow operation to proceed to the next layer (Arm Layer 2). With the Immediate control source selected (:ARM:SOURce IMMediate), operation immediately proceeds to the next layer when the instrument is taken out of the idle state. The *RST and :SYSTem:PRESet commands also set the arm control source to Immediate. With one of the other control sources selected, the instrument will wait until the appropriate event occurs.

With the Manual control source selected (:ARM :SOURce MANual), the instrument will wait until the front panel STEP key is pressed. Note that the Model 7001 must be taken out of remote (press LOCAL key or send LOCAL 707 over bus) before it will respond to the STEP key. With the Bus control source selected (:ARM:SOURce BUS), the instrument will wait until a bus trigger (GET or *TRG) is received. With the External control source selected (:ARM:SOURce EXTernal), the instrument will wait until an input trigger (via EXTERNAL TRIGGER connector on rear panel) is received. With the Trigger Link control source selected (:ARM:SOURce TLINk), the instrument will wait until an input trigger is received (via TRIGGER LINK). With the Hold control source selected (:ARM:SOURce HOLD), the instrument will not respond to any of the control source events.

As can be seen in the flowchart, there are three paths that allow operation to loop around the control source. These three paths are described as follows:

1. When the Source Bypass is enabled (:ARM:TCONfigure:DIRection SOURce) and the External or Trigger Link control source is selected, operation will loop around the control source on the initial pass through Arm Layer 1. If programmed for another arm (arm count > 1), the bypass loop will not be in effect even though it will still be enabled. The Source Bypass loop will reset (be in effect) if operation goes into Idle.

   Enabling the Source Bypass also enables the Output Trigger. When operation returns to Arm Layer 1 from Arm Layer 2, an output trigger pulse will occur. If the Trigger Link control source is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line. For all other control source selections, the output trigger pulse will be available at the CHANNEL READY connector. The Output Trigger in this layer is disabled when the Source Bypass is disabled (:ARM :TCONfigure:DIRection ACCeptor).
2. Each time the :ARM:IMMediate command is sent, operation will loop around the arm control source. It is used when you do not wish to wait for a programmed arm event to occur (or when the Hold control source is selected).
3. Each time the :ARM:SIGNal command is sent, operation will loop around the arm control source. It is used when you do not wish to wait for a programmed arm event to occur (or when the Hold control source is selected).

After all other instrument operations have been completed, the instrument can be returned to Arm Layer 1 by programming the instrument for additional arms. The :ARM:COUNt <n> command can be used to set the arm count to a finite value (where <n> = 1 to 9999) or for an infinite (<n> = INF) number of arms. The *RST and :SYSTem:PRESet commands set the arm count to 1.

After the instrument leaves Arm Layer 1, operation proceeds into the scan layer (Arm Layer 2).

Arm layer2

NOTE

For front panel operation, this layer is called the scan layer.

In general, the instrument requires a scan event to allow operation to proceed to the next layer (trigger layer). With the Immediate control source selected (:ARM:LAYer2:SOURce IMMediate), operation immediately proceeds to the next layer. The *RST and :SYSTem:PRESet commands also set the scan control source to Immediate. With one of the other control sources selected, the instrument will wait until the appropriate event occurs.

With the Timer control source selected (:ARM:LAYer2SOURce TIMer), operation will immediately proceed into the channel layer on the initial pass through Arm Layer 2. Each additional scan will not occur until the programmed timer interval elapses. The timer can be set to an interval from 1msec to 999999.999 seconds.

With the Manual control source selected (:ARM:LAYer2:SOURce MANual), the instrument will wait until the front panel STEP key is pressed. Note that the Model 7001 must be taken out of remote (press LOCAL key or send LOCAL 707 over bus) before it will respond to the STEP key. With the Bus control source selected (:ARM:LAYer2:SOURce BUS), the instrument will wait until a bus trigger is received (GET or *TRG). With the External control source selected (:ARM:LAYer2:SOURce EXTernal), the instrument will wait until an input trigger (via EXTERNAL TRIGGER connector on rear panel) is received. With the Trigger Link control source selected (:ARM:LAYer2:SOURce TLINk), the instrument will wait until an input trigger is received (via TRIGGER LINK). With the Hold control source selected (:ARM:LAYer2:SOURce HOLD), the instrument will not respond to any of the control source events.

After the programmed scan event is detected, the instrument will wait for the programmed Delay to time out. The :ARM:LAYer2:DELay <n> command is used to set the Delay (where n = 0 to 999999.999 seconds). The *RST and :SYSTem:PRESet commands set the Delay to zero seconds.

As can be seen in the flowchart, there are three paths that allow operation to loop around the control source. Two of these paths also loop around the Delay. These three paths are described as follows:

1. When the Source Bypass is enabled (:ARM:TCONfigure:DIRection SOURce) and the External or Trigger Link control source is selected, operation will loop around the control source on the initial pass through arm layer 2. If programmed for another scan (scan count > 1), the bypass loop will not be in effect even though it will still be enabled. The Source Bypass loop will reset (be in effect) if operation goes back into arm layer 1.

   Enabling the Source Bypass also enables the Output Trigger. When operation returns to arm layer 2 from the trigger layer, an output trigger pulse will occur. If the Trigger Link control source is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line. For all other control source selections, the output trigger pulse will be available at the CHANNEL READY connector. The Output Trigger in this layer is disabled when the Source Bypass is disabled (:ARM:TCONfigure:DIRection ACCeptor).
2. Each time the :ARM:LAYer2:IMMediate command is sent, operation will loop around the scan control source and the Delay. It is used when you do not wish to wait for a programmed scan event to occur (or when the Hold control source is selected).
3. Each time the :ARM:LAYer2:SIGNal command is sent, operation will loop around the scan control source. This path functions the same as :ARM:LAYer2:IMMediate except that it does not loop around the Delay.

After all other operations in the next layer have been completed, the instrument can be returned to Arm Layer 2 by programming the instrument for additional scans. The :ARM:LAYer2:COUNt <n> command can be used to set the scan count to a finite value (where <n> = 1 to 9999) or for an infinite (<n> = INF) number of scans. The *RST command sets the scan count to one and the :SYSTem:PRESet command sets the scan count to infinite.

After the instrument leaves arm layer 2, operation proceeds to the Channel Layer (Trigger Layer).

Trigger layer

NOTE

For front panel operation, this layer is called the channel layer.

In general, measure events control the channel scan rate. With the Immediate control source selected (:TRIGger:SOURce IMMediate), operation immediately proceeds to the Delay. The *RST command also sets the measure control source to Immediate. With one of the other control sources selected, the instrument will wait until the appropriate event occurs.

With the Timer control source selected (:TRIGger :SOURce TIMer), the first channel will be scanned immediately. Each additional will be scanned at a rate determined by the programmed timer interval (1msec to 999999.999 seconds).

With the Manual control source selected (:TRIGger :SOURce MANual), the instrument will wait until the front panel STEP key is pressed. Note that the Model 7001 must be taken out of remote (press LOCAL key or send LOCAL 707 over bus) before it will respond to the STEP key. The :SYSTem:PRESet command also selects the Immediate control source.

With the Bus control source selected (:TRIGger :SOURce BUS), the instrument will wait until a bus trigger is received (GET or *TRG). With the External control source selected (:TRIGger:SOURCE EXTernal), the instrument will wait until an input trigger (via EXTERNAL TRIGGER connector on rear panel) is received. With the Trigger Link control source selected (:TRIGger:SOURce TLINk), the instrument will wait until an input trigger is received (via TRIGGER LINK). With the Hold control source selected (:TRIGger :SOURce HOLD), the instrument will not respond to any of the control source events.

After the programmed channel event is detected, the instrument will wait for the programmed Delay to time out. The :TRIGger:DELay <n> command is used to set the Delay (where n = 0 to 999999.999 seconds).

The *RST and :SYSTem:PRESet commands set the Delay to zero seconds.

As can be seen in the flowchart, there are three paths that allow operation to loop around the control source. Two of these paths also loop around the Delay. These three paths are described as follows:

1. When the Source Bypass is enabled (:ARM :TCONfigure:DIRection SOURce) and the External or Trigger Link control source is selected, operation will loop around the control source on the initial pass through the Trigger Layer. If programmed to scan another channel, (channel count > 1), the bypass loop will not be in effect even though it will still be enabled. The Source Bypass loop will reset (be in effect) if operation goes back to Arm Layer 2.
2. Each time the :TRIGger:IMMediate command is sent, operation will loop around the control source and the Delay. It is used when you do not wish to wait for a programmed channel event to occur (or when the Hold control source is selected).
3. Each time the :TRIGger:SIGNal command is sent, operation will loop around the channel control source. This path functions the same as :TRIGger:IMMediate except that it does not loop around the Delay.

At this point the first (or next) channel in the Scan List will be scanned (Device Action). When scanning channels, the previous channel will open and the next channel will close (break-before-make). Also included in the Device Action is the internal settling time delay for the relay and any additional programmed settling time delay using the :STIMe command of the :ROUTe Subsystem (see paragraph 5.13).

After a channel is scanned, an Output Trigger will occur. If the channel control source is programmed for Immediate, Manual, Bus or Timer, the output trigger pulse will be available at the CHANNEL READY connector. If the Trigger Link control source is selected, Output Trigger action will occur as follows:

1. If the asynchronous Trigger Link mode is selected, the output trigger pulse will be available on the programmed TRIGGER LINK output line.
2. If the semi-synchronous Trigger Link mode is selected and the Source Bypass is disabled (:trig :tcon:dir acc), the Trigger Link line will be released (goes high).
3. If the semi-synchronous Trigger Link mode is selected and the Source Bypass is enabled (:trig :tcon:dir sour), the Trigger Link line will be pulled down low and then released.

Note: See paragraph 4.17 for details on using the Trigger Link.

After a channel is scanned and an output trigger occurs, the instrument will (if programmed to do so) return to the beginning of the trigger layer to scan another channel. The :TRIGger:COUNt <n> command is used to set the channel count to a finite value (where <n> = 1 to 9999) or for a continuous scan of the Scan List (<n> = INF). The :TRIGger:COUNt :AUTo ON command is used to automatically set the channel count to the length of the Scan List. The *RST command sets the channel count to one and the :SYSTem:PRESet command enables the automatic channel count.

5.8 General bus commands

General bus commands are those commands such as DCL that have the same general meaning regardless of the instrument. Commands supported by the Model 7001 are listed in Table 5-3 which also lists BASIC statements necessary to send each command. Note that commands requiring that a primary address be specified assume that the primary address is set to 7. This is the address that is set at the factory.

5.8.1 REN (remote enable)

The remote enable command is sent to the Model 7001 by the controller to set up the instrument for remote operation. Generally, the instrument should be placed in the remote mode before you attempt to program it over the bus. Simply setting REN true does not actually place the instrument in the remote state. Instead the instrument must be addressed to listen after setting REN true before it goes into remote.

Note that the instrument need not be in remote to be a talker.

Programming Example — This sequence is automatically performed by the controller when the following is typed into the keyboard.

REMOTE 707

After the RETURN key is pressed, the instrument is in the remote state, as indicated by the REM annunciator. If not, check to see that the instrument is set to the proper primary address 07, and check to see that the bus connections are properly made.

Note that all front panel controls except for LOCAL (and, of course, POWER) are inoperative while the instrument is in remote. You can restore normal front panel operation by pressing the LOCAL key.

Table 5-3
General bus commands and associated BASIC statements

Command	HP BASIC 4.0 statement	Effect on Model 7001
REN	REMOTE 7	Goes into effect when next addressed to listen.
IFC	ABORT 7	Goes into talker and listener idle states.
LLO	LOCAL LOCKOUT 7	LOCAL key locked out.
GTL	LOCAL 707	Cancel remote, restore front panel operation.
DCL	CLEAR 7	Returns 7001 to known conditions.
SDC	CLEAR 707	Returns all devices to known conditions.
GET	TRIGGER 707	Initiates a trigger.
SPE, SPD	SPOLL (707)	Serial Polls the Model 7001.

5.8.2 IFC (interface clear)

The IFC command is sent by the controller to place the Model 7001 in the local, talker, and listener idle states. The unit responds to the IFC command by cancelling front panel TALK or LISTEN lights, if the instrument was previously placed in one of those states.

Note that this command does not affect the status of the instrument; settings, data, and event registers are not changed.

To send the IFC command, the controller need only set the IFC line true for a minimum of 100µsec.

Programming Example — Before demonstrating the IFC command, turn on the TALK indicator with the following statement:

ENTER 707; A$

At this point, the TALK light should be on. The IFC command can be sent by entering the following statement into the computer:

ABORTIO 7

After the RETURN key is pressed, the TALK indicator turns off, indicating that the instrument has gone into the talker idle state.

5.8.3 LLO (local lockout)

The LLO command is used to prevent local operation of the instrument. After the unit receives LLO, all its front panel controls except POWER are inoperative. In this state, pressing LOCAL will not restore control to the front panel.

Programming Example — The LLO command is sent by entering the following statements:

REMOTE 707
LOCAL LOCKOUT 7

After the second statement is executed, the instrument's front panel controls are locked out, including the LOCAL key.

To restore front panel operation after asserting LLO, as in the following example, enter:

LOCAL 7

5.8.4 GTL (go to local) and local

The GTL command is used to take the instrument out of the remote state. Operation of the front panel keys is restored. If LLO is in effect, the front panel LOCAL key will be disabled when the Model 7001 is put into remote. To cancel LLO, you must set REN false.

Programming Example — Place the instrument in the remote state with the following statement:

REMOTE 707

Now send GTL with the following statement:

LOCAL 707

Note that the instrument goes into the local state, and that operation of the front panel keys has now been restored (assuming that LLO is not in effect).

5.8.5 DCL (device clear)

The DCL command may be used to clear the Model 7001 and return it to a known state. Note that the DCL command is not an addressed command, so all instruments equipped to implement DCL will do so simultaneously.

When the Model 7001 receives a DCL command, it will clear the Input Buffer and Output Queue, cancel deferred commands, and clear any command that prevents the processing of any other device command. A DCL will not affect instrument settings, stored data, the channel list or scan list.

Programming Example — Use the following statement to perform a DCL:

CLEAR 7

When the RETURN key is pressed, the instrument will perform the DCL.

5.8.6 SDC (selective device clear)

The SDC command is an addressed command that performs essentially the same function as the DCL command. However, since each device must be individually addressed, the SDC command provides a method to clear only selected instruments instead of clearing all instruments simultaneously, as is the case with DCL.

Programming Example — Use the following statement to perform an SDC:

CLEAR 707

This sends the following IEEE-488 commands: UNT UNL LISTEN 07 SDC. When the statement is executed, the instrument performs the SDC.

5.8.7 GET (group execute trigger)

GET is a GPIB trigger that is used as an arm, scan and/or channel event to control the scanning process. The Model 7001 will react to this trigger if it is the programmed control source. The control source is programmed from the SCPI :TRIGger Subsystem (see paragraph 5.18).

With the instrument programmed and waiting for a GPIB trigger, the following programming statement will provide the GET:

TRIGGER 707

This sends IEEE-488 commands UNT UNL LISTEN 07 GET. When the ENTER key is pressed, the trigger event occurs. (The command TRIGGER 7 just sends GET. Any other listeners are triggered when the ENTER key is pressed.)

5.8.8 SPE, SPD (serial polling)

The serial polling sequence is used to obtain the Model 7001 serial poll byte. The serial poll byte contains important information about internal functions, as described in paragraph 5.6.8. Generally, the serial polling sequence is used by the controller to determine which of several instruments has requested service with the SRQ line. However, the serial polling sequence may be performed at any time to obtain the status byte from the Model 7001.

Programming Example — The SPOLL statement automatically performs the serial poll sequence. To demonstrate serial polling, enter in the following statements into the computer:

```
S=SPOLL (707)
PRINT "SPOLL BYTE =";S
```

After the first statement, the controller conducts the serial polling sequence. After the second statement is executed, the decimal value of the serial poll byte is displayed on the controller CRT.

5.9 Programming syntax

The following programming syntax information covers both common commands and SCPI commands. For information not covered here, refer to the documentation for the IEEE-488.2 standard and SCPI.

Command words

One or more command words make up the program message that is sent to the computer to perform one or more operations.

1. **Commands and command parameters:** Both common commands and SCPI commands may or may not use a parameter. Examples:

*SAV 0	Parameter (0) required.
*RST	No parameter used with this command.
:INITiate:CONTinuous <b>	Parameter (<b>) required.
:SYSTem:PRESet	No parameter used with this command.

Note that there must be at least one space between the command word and the parameter.

Brackets [ ]: Throughout this manual, you will find command words that are enclosed in brackets ([]). These brackets are simply used to denote an optional command word that does not need to be included in the program message. For example:

:INITiate[:IMMediate]

The brackets indicate that :IMMediate is implied (optional) and does not have to be used. Thus, the above command can be sent in one of two ways:

:INITiate or :INITiate:IMMediate

Notice that the optional command is used without the brackets. **Do not include the brackets when using an optional command word.**

Parameter types: Some of the more common parameter types used in this manual are explained as follows:

<b>	Boolean: Used to enable or disable an instrument operation. In general, 0 or OFF disables the operation, and 1 or ON enables the operation. Specifically, a Boolean parameter is processed as follows:

- While ignoring the sign (+ or -), the parameter value is rounded to an integer.
- A zero result is interpreted as OFF, and a non-zero result is interpreted as ON.

  Example:

  :INITiate:CONTinuous ON   Enable continuous initiation

<name> Name parameter: Select a parameter name from a listed group. Example:

<name> = AHIGH
= ALOW

:OUTPut:TTL:LSENse AHIGH

<NRf> Numeric representation format: This parameter is a number that can be expressed as an integer (e.g., 8), a real number (e.g., 23.6) or an exponent (2.3E6) When necessary, the Model 7001 will round real and exponential parameter values to an integer. Example:

:SAV 36   Save setup in memory location 36.

<n> Numeric value: A numeric value parameter can consist of an NRf number or one of the following name parameters; DEFault, MINimum or MAXimum. When the DEFault parameter is used, the instrument will be programmed to the *RST default value. When the MINimum parameter is used, the instrument will be programmed to the lowest allowable value. When the MAXimum parameter is used, the instrument will be programmed to the largest allowable value. Examples:

:TRIGger:TIMer	0.1	Sets timer to 100msec.
:TRIGger:TIMer	DEFault	Sets timer to 1msec.
:TRIGger:TIMer	MINimum	Sets timer to 1msec.
:TRIGger:TIMer	MAXimum	Sets timer to 999999.999sec.

<list> List: This parameter type is used to indicate that a list of channels is required with the command word. The following example demonstrates the proper format for specifying a list:

:CLOSe (@ 1!1, 1!3)   Close channels 1 and 3 of Slot 1.

Angle brackets < >: In this manual, angle brackets (<>) are used to denote parameter type. **Do not** include the brackets in the program message. For example:

:SOURce:TTL2 <b>

The <b> indicates that a Boolean type parameter is required. Thus, to set digital input line #2 true, you must send the command with the ON or 1 parameter as follows:

:SOURce:TTL2 ON or :SOURce:TTL2 1

2. **Query commands:** This type of command requests (queries) the currently programmed status. It is identified by the question mark (?) at the end of the fundamental form of the command. Most commands have a query form. Examples:

*OPT?	Common query command.
:TRIGger:TIMer?	SCPI query command.

All commands that require a numeric parameter (<n>) can also use the DEFault, MINimum, and MAXimum parameters for the query form. These query forms are used to determine the *RST default value, and the upper and lower limits for the fundamental command. Examples:

:TRIGger:TIMer?	DEFault	Queries the *RST default value.
:TRIGger:TIMer?	MINimum	Queries the lowest allowable value.
:TRIGger:TIMer?	MAXimum	Queries the largest allowable value.

3. **Case sensitivity:** Common commands and SCPI commands are not case sensitive. You can use upper or lower case, and any case combination. Examples:

*RST = *rst
:SCAN? = :scan?
:SYSTem:PRESet = :system:preset

4. **Long-form and short-form versions:** A SCPI command word can be sent in its long-form or short-form version. The command subsystem tables in this section provide the commands in the long-form version. However, the short-form version is indicated by upper case characters. Examples:

:SYSTem:PRESet	Long-form
:SYST:PRES	Short-form
:SYSTem:PRES	Long and short-form combination

Note that each command word must be in long-form or short-form, and not something in between. For example, :SYSTe:PRESe is illegal and will generate an error. The command will not be executed.

There are no short-form versions for common commands.

Short-form rules: The following rules can be used to determine the short-form version of any SCPI command:

A. If the length of the command word is four letters or less, there is no short-form version. Examples:

:open = :open
:line = :line

B. The following rules apply to command words that exceed four letters:

a. If the fourth letter of the command word is a vowel, delete it and all the letters after it. Examples:

:immediate = :imm
:timer = :tim

b. If the fourth letter of the command word is a consonant, retain it but drop all the letters after it. Examples:

:output = :outp
:asynchronous = :asyn

C. If there is a question mark (?; query) or a non-optional number included in the command word, it must be included in the short-form version. Examples:

:delay? = :del?
:layer2 = :lay2

D. As previously explained, command words or characters that are enclosed in brackets ([]) are optional and need not be included in the program message. Example:

:STATus:OPERation[:EVENt]?

The brackets ([]) indicate that :EVENt is optional. Thus, either of the following two command program messages are valid:

:STATus:OPERation:EVENt? = :STATus:OPERation?

Notice that when using the optional word or character, the brackets ([]) are not included in the program message.

The complete short-form version of the above command is as follows:

:stat:oper?

Program messages

A program message is made up of one or more command words sent by the computer to the instrument. Each common command is simply a three letter acronym preceded by an asterisk (*). SCPI commands are categorized into subsystems and are structured as command paths. The following command paths are contained in the :STATus subsystem and are used to help explain how command words are structured to formulate program messages.

```
:STATus                          Path (Root)
  :OPERation                       Path
    :PTRansition  <NRf>              Command and parameter
    :NTRansition  <NRf>              Command and parameter
    :ENABle  <NRf>                   Command and parameter
  :PRESet                          Command
```

1. **Single command messages:** There are three levels to the above command structure. The first level is made up of the root command (:STATus) and serves as a path. The second level is made up of another path (:OPERation) and a command (:PRESet). The third path is made up of three commands for the :OPERation path. The four commands in this structure can be executed by sending four separate program messages as follows:

   ```
   :stat:oper:ptr  <NRf>
   :stat:oper:ntr  <NRf>
   :stat:oper:enab  <NRf>
   :stat:pres
   ```

   In each of the above program messages, the path pointer starts at the root command (:stat) and moves down the command levels until the command is executed.

2. **Multiple command messages:** Multiple commands can be sent in the same program message as long as they are separated by semicolons (;). Example showing two commands in one program message:

   ```
   :stat:pres; :stat:oper:enab  <NRf>
   ```

   When the above message is sent, the first command word is recognized as the root command (:stat). When the next colon is detected, the path pointer moves down to the next command level and executes the command. When the path pointer sees the colon after the semicolon (;), it resets back to the root level and starts over.

   Commands that are on the same command level can be executed without having to retype the entire command path. Example:

   ```
   :stat:oper:enab  <NRf>; ptr  <NRf>; ntr  <NRf>
   ```

   After the first command (:enab) is executed, the path point is at the third command level in the structure. Since :ptr and :ntr are also on the third level, they can be typed in without repeating the entire path name. Notice that the leading colon for :ptr and :ntr are not included in the program message. If a colon were included, the path pointer would reset to the root level and expect a root command. Since neither :ptr nor :ntr are root commands, an error would occur.

3. **Command path rules:**

   A. Each new program message must begin with the root command, unless it is optional (e.g., [:SENSe]). If the root is optional, simply treat a command word on the next level as the root.

   B. The colon (:) at the beginning of a program message is optional and need not be used. Example:

   ```
   :stat:pres   = stat:pres
   ```

   C. When the path pointer detects a colon (:) it will move down to the next command level. An exception is when the path pointer detects a semicolon (;), which is used to separate commands within the program message (see next rule).

   D. When the path pointer detects a colon (:) that immediately follows a semicolon (;), it resets back to the root level.

   E. The path pointer can only move down. It cannot be moved up a level. Executing a command at a higher level requires that you start over at the root command.

4. **Using common commands and SCPI commands in same message:** Both common commands and SCPI commands can be used in the same message as long as they are separated by semicolons (;). A common command can be executed at any command level and will not affect the path pointer. Example:

   ```
   :stat:oper:enab   <NRf>; ptr   <NRf>; *ESE   <NRf>; ntr   <NRf>
   ```

5. **Program Message Terminator (PMT):** Each program message must be terminated with an LF (line feed), EOI (end or identify) or an LF + EOI. The bus will hang if your computer does not provide this termination. The following example shows how a multiple command program message must be terminated:

   ```
   :rout:open   all; scan   (@1:5) <PMT>
   ```

6. Command execution rules:

   A. Commands are executed in the order that they are presented in the program message.

   B. An invalid command will generate an error and, of course, not be executed.

   C. Valid commands that precede an invalid command in a multiple command program message will be executed.

   D. Valid commands that follow an invalid command in a multiple command program message will be ignored. Example:

   ```
   :rout:open   all; harve; scan?
   ```

   :open all will execute. Harve is an invalid command and will generate an error. The scan query will be ignored.

Response messages

A response message is the message sent by the instrument to the computer in response to a query command program message.

1. **Sending a response message:** After sending a query command, the response message is placed in the Output Queue. When the Model 7001 is then addressed to talk, the response message is sent from the Output Queue to the computer. The following example in HP BASIC 4.0 demonstrates this process:

```
10   OUTPUT 707; ":rout:scan?"      ! Send query command.
20   ENTER 707; A$                  ! Address Model 7001 to talk.
30   PRINT A$                       ! Display response message on CRT.
40   END
```

   There are two special query commands that are used to read the Error Queue. As error and status messages occur they are stored in the Error Queue. This queue is a first-in first-out (FIFO) register. Either of the following two SCPI commands can be used to read the Error Queue:

   :STATus:QUEue?
   :SYSTem:ERRor?

   After sending either of the above commands, the oldest message in the Error Queue will be moved to the Output Queue. When the Model 7001 is then addressed to talk (as explained above), the response message will be sent to the computer.

2. **Multiple response messages:** If you send more than one query command in the same program message (see Multiple command messages), the multiple response message for all the queries will be sent to the computer when the Model 7001 is addressed to talk. The responses are sent in the order that the query commands were sent and will be separated by semicolons (;). Items within the same query are separated by commas (,). The following example shows the response message for a program message that contains four single item query commands:

   0; 1; 1; 0

3. **Response Message Terminator (RMT):** Each response message is terminated with an LF (line feed) and EOI (end or identify). The following example shows how a multiple response message is terminated:

   0; 1; 1; 0 <RMT>

Message exchange protocol

The message exchange protocol can be summarized by the two following rules:

Rule 1. You must always tell the Model 7001 what to send to the computer.

The following two steps must always be performed, in this order, to send information from the instrument to the computer:

1. Send the appropriate query command(s) in a program message.
2. Address the Model 7001 to talk.

Rule 2. The complete response message (including the RMT) must be received by the computer before another program message can be sent to the Model 7001.

5.10 Common commands

Common commands are device commands that are common to all devices on the bus. These commands are designated and defined by the IEEE-488.2 standard.

Table 5-4 summarizes the common commands used by the Model 7001 and are presented in alphabetical order. The following detailed descriptions include programming examples using HP BASIC 4.0.

Programming syntax information for common commands and SCPI commands is located just after the tab labled "SCPI Command Subsystems".

Table 5-4
IEEE-488.2 common commands and queries

Mnemonic	Name	Description	Para.
*CLS	Clear status	Clears all event registers, and Error Queue.	5.10.1
*ESE <NRf>	Event status enable command	Sets the contents of the Standard Event Status Enable Register.	5.10.2
*ESE?	Event status enable query	Request the programmed value of the Standard Event Status Enable Register.	5.10.3
*ESR?	Event status register query	Request the programmed value of the Standard Event Status Register and clears it.	5.10.4
*IDN?	Identification query	Request the manufacturer, model number, serial number, and firmware revision levels of the unit.	5.10.5
*OPC	Operation complete command	Sets the Operation Complete bit in the Standard Event Status Register after all pending commands have been executed.	5.10.6
*OPC?	Operation complete query	Places an ASCII “1” into the output queue when all pending selected device operations have been completed.	5.10.7
*OPT?	Option identification query	Request the assigned model number for all slots.	5.10.8
*RCL <NRf>	Recall command	Returns the Model 7001 to the setup configuration stored in the designated memory location.	5.10.9
*RST	Reset command	Returns the Model 7001 to the *RST default conditions.	5.10.10
*SAV <NRf>	Save command	Saves the current setup configuration to the designated memory location.	5.10.11
*SRE <NRf>	Service request enable command	Sets the contents of the Service Request Enable Register.	5.10.12
*SRE?	Service request enable query	The Model 7001 returns the value of the Service Request Enable Register.	5.10.13
*STB?	Read status byte query	Returns the value of the Status Byte Register.	5.10.14
*TRG	Trigger command	This command issues a bus trigger which has the same effect as group execute trigger (GET) command.	5.10.15
*TST?	Self-test query	When this query is sent, the Model 7001 will perform a checksum test on ROM and return the results.	5.10.16
*WAI	Wait-to-continue command	Wait until all previous commands are executed.	5.10.17

Note: At least one space is required between the command and the parameter.

5.10.1 *CLS — clear status

Purpose

To clear status registers and error queue.

Format

***CLS**

Description

The *CLS command is used to clear (reset to 0) the bits of the following registers in the Model 7001:

Standard Event Status Register
Operation Event Register
Questionable Event Register
Error Queue
Trigger Event Register
Sequence Event Register
Arm Event Register

This command also forces the instrument into the operation complete command idle state and operation complete query idle state.

Programming example

```
OUTPUT 707; "*CLS"          ! Clear registers and Error Queue
```

5.10.2 *ESE — event status enable

Purpose To set the contents of the Standard Event Status Enable Register.

Format ***ESE <NRf>**

Parameters

<NRf>	= 0	Clear (reset) register
	= 1	Set OPC (B0) of enable register
	= 4	Set QYE (B2) of enable register
	= 8	Set DDE (B3) of enable register
	= 16	Set EXE (B4) of enable register
	= 32	Set CME (B5) of enable register
	= 64	Set URQ (B6) of enable register
	= 128	Set PON (B7) of enable register

Defaults

Power-up	Clears register
*CLS	No effect
*RST	No effect
:STATus:PRESet	No effect
DCL, SDC	No effect

Description

The *ESE command is used to set the contents of the Standard Event Status Enable Register. This command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of the bits in the register.

This register is used as a mask for the Standard Event Status Register. When a standard event is masked, the occurrence of that event will not set the Event Summary Bit (ESB) in the Status Byte Register. Conversely, when a standard event is unmasked (enabled), the occurrence of that event will set the ESB bit. For information on the Standard Event Status Register and descriptions of the standard event bits, see paragraph 5.10.4. The Status Byte Register is described in paragraph 5.6.8.

A cleared bit (bit set to “0”) in the enable register will prevent (mask) the ESB bit in the Status Byte Register from setting when the corresponding standard event occurs. A set bit (bit set to “1”) in the enable register will allow (enable) the ESB bit to set when the corresponding standard event occurs. For details on the status register structure, refer to paragraph 5.6.

The Standard Event Status Enable Register is shown in Figure 5-13. Notice that the decimal weight of each bit is included in the illustration. The sum of the decimal weights of the bits that you wish to be set is the value that is sent with the *ESE command. For example, to set the CME and QYE bits of the Standard Event Status Enable Register, send the following command:

```
*ESE 36
```

where; CME (bit B5) = Decimal 32
QYE (bit B2) = Decimal 4
parameter = 36

If a command error (CME) occurs, bit B5 of the Standard Event Status Register will set. If a query error (QYE) occurs, bit B2 of the Standard Event Status Register will set. Since both of these events are unmasked (enabled), the occurrence of any one of them will cause the ESB bit in the Status Byte Register to set.

The contents of the Standard Event Status Event Register can be read by using the *ESE? query command (see next paragraph).

Programming example

OUTPUT 707; "*ESE 24" ! Set bits B3 (EXE) and B4 (DDE) of the Standard Event Status Enable Register.

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	PON	URQ	CME	DDE	EXE	QYE	—	OPC
Decimal Weighting	128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	—	1 (2^0)
Value	0/1	0/1	0/1	0/1	0/1	0/1	—	0/1

Value : 1 = Enable Standard Event
0 = Disable (Mask) Standard Event

Events : PON = Power On
URQ = User Request
CME = Command Error
DDE = Device-dependent Error
EXE = Execution Error
QYE = Query Error
OPC = Operation Complete

Figure 5-13
Standard Event Status Enable Register

5.10.3 *ESE? — event status enable query

Purpose To read the contents of the Standard Event Status Enable Register.

Format ***ESE?**

Description This command is used to acquire the value (in decimal) of the Standard Event Status Enable Register. The binary equivalent of the decimal value determines which bits in the register are set. When the *ESE? query command is sent, the decimal value is placed in the Output Queue. When the Model 7001 is addressed to talk, the value is sent from the Output Queue to the computer.

For example, for an acquired decimal value of 48, the binary equivalent is 00110000. For this binary value, bits B4 and B5 of the Standard Event Status Enable Register are set. For information on the Standard Event Status Enable Register, refer to paragraph 5.6.

The *ESE? query command does not clear the Standard Event Status Enable Register.

Programming example

```
10   OUTPUT 707; "*ESE?"      ! Send query command
20   ENTER 707; A$            ! Address 7001 to talk
30   PRINT A$                 ! Display value of register contents
40   END
```

5.10.4 *ESR? — event status register query

Purpose To read the contents of the Standard Event Status Register and clear it.

Format ***ESR?**

Defaults

Power-up	Clears register
*CLS	Clears register
*RST	No effect
:STATus:PRESet	No effect
DCL, SDC	No effect

Description This command is used to acquire the value (in decimal) of the Standard Event Status Register (see Figure 5-14). The binary equivalent of the returned decimal value determines which bits in the register are set. When the *ESR? command is sent, the decimal value is placed in the Output Queue and the Standard Event Status Register is cleared. When the Model 7001 is addressed to talk, the value in the Output Queue is sent to the computer.

A set bit in this register indicates that a particular event has occurred. For example, for an acquired decimal value of 48, the binary equivalent is 0011 0000. For this binary value, bits B4 and B5 of the Standard Event Status Register are set. These set bits indicate that a device-dependent error and command error have occurred.

The bits of the Standard Event Status Register are described as follows:

Bit B0, Operation Complete (OPC) — Set bit indicates that all pending selected device operations are completed and the Model 7001 is ready to accept new commands. This bit will only set in response to the *OPC? query command (see paragraph 5.10.7).

Bit B1 — Not Used

Bit B2, Query Error (QYE) — Set bit indicates that you attempted to read data from an empty Output Queue.

Bit B3, Device-dependent Error (DDE) — Set bit indicates that an instrument operation did not execute properly due to some internal condition.

Bit B4, Execution Error (EXE) — Set bit indicates that the Model 7001 detected an error while trying to execute a command.

Bit B5, Command Error (CME) — Set bit indicates that a command error has occurred. Command errors include:

1. IEEE-488.2 syntax error: Model 7001 received a message that does not follow the defined syntax of the IEEE-488.2 standard.

2. Semantic error: Model 7001 received a command that was misspelled, or received an optional IEEE-488.2 command that is not implemented.
3. The instrument received a Group Execute Trigger (GET) inside a program message.

Bit B6, User Request (URQ) — Set bit indicates that the LOCAL key on the Model 7001 front panel was pressed.

Bit B7, Power On (PON) — Set bit indicates that the Model 7001 has been turned off and turned back on since the last time this register has been read.

Programming example

```
10   OUTPUT 707; "*ESE?"     ! Request register value
20   ENTER 707; A$           ! Address 7001 to talk
30   PRINT A$                ! Display value
```

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	PON	URQ	CME	EXE	DDE	QYE	—	OPC
Decimal Weighting	128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	—	1 (2^0)
Value	0/1	0/1	0/1	0/1	0/1	0/1	—	0/1

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Events : PON = Power On
URQ = User Request
CME = Command Error
EXE = Execution Error
DDE = Device-dependent Error
QYE = Query Error
OPC = Operation Complete

Figure 5-14
Standard Event Status Register

5.10.5 *IDN? — identification query

Purpose To read the identification code of the Model 7001.

Format ***IDN?**

Description The *IDN? query command places the identification code of the Model 7001 in the Output Queue. When the Model 7001 is addressed to talk, the identification code will be sent to the computer.

The identification code includes the manufacturer, model number, serial number, and firmware revision levels, and is sent in the following format:

KEITHLEY INSTRUMENTS INC., MODEL 7001, wwwwwww, xxxxx,/yyyyy/zzzzz

where; wwwwwww is the serial number
xxxxx is the firmware revision level of the digital board
yyyyy is the firmware revision level of the VFD display
zzzzz is the firmware revision level of the LED display

Programming example

```
10    OUTPUT 707; "*IDN?"      ! Request 7001 ID data
20    ENTER 707; A$            ! Address 7001 to talk
30    PRINT A$                 ! Display identification code
```

5.10.6 *OPC — operation complete

Purpose To set the Operation Complete bit in the Standard Event Status Register after all overlapped commands are complete.

Format ***OPC**

Description On power-up, or when *CLS or *RST is executed, the Model 7001 goes into the Operation Complete Command Idle State (OCIS). In this state there are no pending overlapped comamnds. There are three overlapped commands used by the Model 7001:

:INITiate
:INITiate:CONTinuous ON
*TRG

When the *OPC command is sent, the Model 7001 exits from OCIS and enters the Operation Complete Command Active State (OCAS). In OCAS, the instrument continuously monitors the No-Operation-Pending flag. After the last pending overlapped command is complete (No-Operation-Pending flag set to true), the Operation Complete (OPC) bit in the Standard Event Status Register sets, and the instrument goes back into OCIS.

Note that the instrument always goes into OCAS when *OPC is executed. If there are no pending command operations (e.g. trigger model in idle state), the Model 7001 immediately sets the OPC bit and returns to OCIS.

When used with the :INITiate or :INITiate:CONTinuous ON command, the OPC bit of the Standard Event Status Register will not set until the Model 7001 goes back into the idle state. The initiate operations are not considered finished until the instrument goes into the idle state.

When used with the *TRG comamnd, the OPC bit will not set until the operations associated with the *TRG command (and the initiate command) are finished. The *TRG command is considered to be finished when the Device Action completes or when operation stops at a control source to wait for an event (see Trigger Model in paragraph 5.7).

In order to use *OPC exclusively with the *TRG command you will have to first force the completion of the initiate command so that only the *TRG command is pending. To do this, use the :INITiate:CONTinuous ON command to start the scan and then send the :ABORT command. The abort command places the instrument in the idle layer, which (by definition) completes the initiate command. Since continuous initiation is on, operation will continue on into the Trigger Model. After sending the *TRG command, the OPC bit will set when the *TRG command is finished.

NOTE

See *OPC?, *TRG and *WAI for more information.

Programming example

```
10    OUTPUT 707; “:open   all”
20    OUTPUT 707; “*RST”
30    OUTPUT 707; “:scan   (@ 1!1:1!10)”
40    OUTPUT 707; “:trig:coun:auto   on”
50    OUTPUT 707; “:trig:del   0.5”
60    OUTPUT 707; “:init”
70    OUTPUT 707; “*OPC”
80    OUTPUT 707; “*ESR?”
90    ENTER 707; A$
100   PRINT A$
110   END
```

Line 10	Opens all channels.
Line 20	Selects default configuration (see Table 5-6).
Line 30	Defines scan list (channels 1 through 10).
Line 40	Enables automatic scan-list-length for channel count.
Line 50	Sets a 0.5 second delay between each channel.
Line 60	Starts the scan (takes 7001 out of idle state).
Line 70	Set OPC bit after the scan ends.
Line 80	Request value of Standard Event Status Register.
Line 90	Address 7001 to talk.
Line 100	Display value of register (Bit 0 will be set).

When the above program is run, channels 1 through 10 will be scanned and then, at the end of the scan, Bit 0 in the Standard Event Status Register will set. The register is then read to verify that Bit 0 is set.

5.10.7 *OPC? — operation complete query

Purpose Place a "1" in the Output Queue after all overlapped commands are completed.

Format ***OPC?**

Description

On power-up, or when *CLS or *RST is executed, the Model 7001 goes into the Operation Compee Command Query Idle State (OQIS). In this state there are no pending overlapped commands. There are three overlapped commands used by the Model 7001:

:INITiate
:INITiate:CONTinuous ON
*TRG

When the *OPC? command is sent, the Model 7001 exits from OQIS and enters the Operation Complete Command Active State (OQAS). In OQAS, the instrument continuously monitors the No-Operation-Pending flag. After the last pending overlapped command is completed (No-Operation-Pending flag set to true), an ASCII character "1" is placed into the Output Queue, the Message Available (MAV) bit in the Status Byte sets, and the instrument goes back into OQIS. Addressing the Model 7001 to talk will send the ASCII "1" to the computer.

Note that the instrument always goes into OQAS when *OPC? is executed. If there are no pending command operations (e.g. trigger model in idle state), the Model 7001 immediately places an ASCII "1" in the Output Queue, sets the MAV bit and returns to OQIS.

When used with the :INITiate or :INITiate:CONTinuous ON command, an ASCII "1" will not be sent to the Output Queue and the MAV bit will not set until the Model 7001 goes back into the idle state. The initiate operations are not considered finished until the instrument goes into the idle state.

When used with the *TRG command, an ASCII "1" will not be placed into the Output Queue and the MAV bit will not set until the operations associated with the *TRG command (and the initiate command) are finished. The *TRG command is considered to be finished when the Device Action completes or when operation stops at a control source to wait for an event (see Trigger Model in paragraph 5.7).

In order to use *OPC? exclusively with the *TRG command you will have to first force the completion of the initiate command so that only the *TRG command is pending. To do this, use the :INITiate:CONTinuous ON command to start the scan and then send the :ABORT command. The abort command places the instrument in the idle layer, which (by definition) completes the initiate command. Since continuous initiation is on, operation will continue on into the Trigger Model. After sending the *TRG command, an ASCII "1" will be place in the Output Queue and the MAV bit will set when the *TRG command is finished.

After *OPC? is executed, additional commands cannot be sent to the Model 7001 until the pending overlapped commands have finished. For example, :INITiate:CONTinuous ON followed by *OPC? will lock up the instrument and will require a device clear (DCL or SDC) before it will accept any more commands.

NOTE

See *OPC, *TRG and *WAI for more information.

Programming example

```
10    OUTPUT 707; “:open  all”
20    OUTPUT 707; “*RST”
30    OUTPUT 707; “:scan  (@ 1!1:1!10)”
40    OUTPUT 707; “:trig:coun:auto  on”
50    OUTPUT 707; “:trig:del  0.5"
60    OUTPUT 707; “:init”
70    OUTPUT 707; “*OPC?”
80    ENTER 707; A$
90    PRINT A$
100   OUTPUT 707; “*STB?”
110   ENTER 707; B$
120   PRINT B$
130   END
```

Line 10	Opens all channels.
Line 20	Selects default configuration (see Table 5-5).
Line30	Defines scan list (channels 1 through 10).
Line 40	Enables automatic scan-list-length for channel count.
Line 50	Sets a 0.5 second delay between each channel.
Line 60	Starts the scan (takes 7001 out of idle state).
Line 70	Place a “1” in the Output Queue after the scan ends.
Line 80	Address the 7001 to talk.
Line 90	Display the contents of the Output Queue (“1”).
Line 100	Request value of Status Byte Register.
Line 110	Address 7001 to talk.
Line 120	Display value of register (B4 will be set).

When the above program is run, channels 1 through 10 will be scanned and then, at the end of the scan, an ASCII “1” will be placed in the Output Queue. The Output Queue and Status Byte Register will then be read to verify the contents.

5.10.8 *OPT? — option identification query

Purpose

To read the identification code of optional switch cards installed in the Model 7001.

Format

***OPT?**

Description

The *OPT? query command places the option identification code in the Output Queue. When the Model 7001 is addressed to talk, the code is sent from the Output Queue to the computer.

The option identification code indicates the assigned model number for each slot of the mainframe. For example, if a Model 7011 is installed in slot 1 and slots 2 is empty, the following message will be sent to the computer:

```
7011, NONE
```

Programming example

```
10   DIM A$[50]
20   OUTPUT 707; "*OPT?"      ! Request option ID code
30   ENTER 707; A$            ! Address 7001 to talk
40   PRINT A$                 ! Display option ID code
```

5.10.9 *RCL — recall

Purpose To return the Model 7001 to a setup configuration previously stored in memory.

Format ***RCL <n>**

Parameters <NRf> = 0 to 9 Memory location

Description The Model 7001 can store up to 10 setup configurations in memory locations 0 to 9. Over the bus, the *SAV command is used to save setup configurations (see paragraph 5.10.11).

The *RCL command is used to return the Model 7001 to a setup configuration stored at one of the memory locations. For example, if a setup configuration was previously stored at memory location 9, the Model 7001 can be returned to those setup conditions by sending the following command:

```
*RCL   9
```

Note: The Model 7001 is shipped from the factory with :SYSTem:PRESet defaults stored in all ten memory locations (see Table 5-5).

Programming example The following example assumes that a setup configuration has been stored at memory location 6 (see paragraph 5.10.11 for information on storing setup configurations).

```
OUTPUT 707; "*RCL   6"          ! Recall setup stored at memory location 6.
```

5.10.10 *RST — reset

Purpose To reset the Model 7001.

Format ***RST**

Description When the *RST command is sent, the Model 7001 performs the following operations:

1. Returns the Model 7001 to the *RST default conditions (see Table 5-5).
2. Cancels all pending commands.
3. Cancels response to any previously received *OPC and *OPC? commands.

The following instrument states are not affected by this command:

IEEE-488 address
Standard Event Status Register
Status Byte Register

Programming example

```
OUTPUT 707; "*RST"                ! Return 7001 to *RST defaults
```

Table 5-5
Default conditions

Command name	*RST value	:SYSTem:PRESet value
:INITiate		
:CONTinuous	OFF	OFF
:ARM		
:SEQuence[1]		
:LAYer[1]		
:COUNt	1	1
:SOURce	IMMediate	IMMediate
:TCONfigure		
:DIRection	ACCeptor	ACCeptor
:ASYNchronous		
:ILINe	1	1
:OLINe	2	2
:LAYer2		
:COUNt	1	INFinite
:DELay	0	0
:SOURce	IMMediate	IMMediate
:TIMer	0.001	0.001
:TCONfigure		
:DIRection	ACCeptor	ACCeptor
:ASYNchronous		
:ILINe	1	1
:OLINe	2	2
:TRIGger		
:SEQuence1		
:COUNt	1	Scan list length
:AUTO	OFF	ON
:DELay	0	0
:SOURce	IMMediate	MANual
:TIMer	0.001	0.001
:TCONfigure		
:PROTocol	ASYNchronous	ASYNchronous
:DIRection	ACCeptor	SOURce
:ASYNchronous		
:ILINe	1	1
:OLINe	2	2
:SSYNchronous		
:LINE	1	1
[:ROUTe]		
:CONFigure		
:BBMake	ON	ON
:SLOT[1]		
:STIMe	0	0
:SLOT2		
:STIMe	0	0
:CPAir	OFF	OFF
:SCHannel	OFF	OFF
:DISPlay		
:SMESsage	OFF	OFF
:WINDow3		
:GRATicule	ON	ON

5.10.11 *SAV — save

Purpose

To save the current setup configuration in memory.

Format

***SAV <NRf>**

Parameters

<NRf> = 0 to 9	Memory location

Description

The Model 7001 can store up to 10 setup configurations at memory locations 0 to 9 by using the *SAV command. For example, to store the current setup configuration at memory location 6, send the following command:

```
*SAV   6
```

Table 5-5 lists the setup items (along with the bus commands to program them), that can be saved by the *SAV command. The *RCL command is used to return the instrument to a saved setup.

Programming example

```
OUTPUT 707; "*SAV   6"            ! Store setup at memory location 6.
```

5.10.12 *SRE — service request enable

Purpose

To set the contents of the Service Request Enable Register.

Format

***SRE <NRf>**

Parameters

<NRf> = 0 Clears enable register
= 4 Set EAV bit (Bit 2)
= 8 Set QSB bit (Bit 3)
= 16 Set MAV bit (Bit 4)
= 32 Set ESB bit (Bit 5)
= 128 Set OSB bit (Bit 7)

Defaults

Power-up	Clears register
*CLS	No effect
*RST	No effect
:STATus:PRESet	No effect
DCL, SDC	No effect

Description

The *SRE command is used to set the contents of the Service Request Enable Register. This command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of each bit in the register.

This enable register is used along with the Status Byte Register to generate service requests (SRQ). With a bit in the Service Request Enable Register set, an SRQ will occur when the corresponding bit in the Status Byte Register is set by an appropriate event. For details on register structure, refer to paragraph 5.6.

The Service Request Enable Register is shown in Figure 5-15. Notice that the decimal weight of each bit is included in the illustration. The sum of the decimal weights of the bits that you wish to set is the value that is sent with the *SRE command. For example, to set the ESB and MAV bits of the Service Request Enable Register, send the following command:

```
*SRE 34
```

where; ESB (bit B5) = Decimal 32
MAV (bit B4) = Decimal 16

<NRf> = 48

The contents of the Service Request Enable Register can be read using the *SRE? query command (see next paragraph).

Programming example

```
OUTPUT 707; "*SRE   32"          ! Set ESB bit
```

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	OSB	—	ESB	MAV	QSB	EAV	—	—
Decimal Weighting	128 (2^7)	—	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	—	—
Value	0/1	—	0/1	0/1	0/1	0/1	—	—

Value : 1 = Enable Service Request Event
0 = Disable (Mask) Service Request Event

Events : OSB = Operation Summary Bit
ESB = Event Summary Bit
MAV = Message Available
QSB = Questionable Summary Bit
EAV = Error Available

Figure 5-15
Service Request Enable Register

5.10.13 *SRE? —service request enable query

Purpose To read the contents of the Service Request Enable Register.

Format ***SRE?**

Description The *SRE? command is used to acquire the value (in decimal) of the Service Request Enable Register. The binary equivalent of the decimal value determines which bits in the register are set. When the *SRE? query command is sent, the decimal value is placed in the Output Queue. When the Model 7001 is addressed to talk, the value is sent from the Output Queue to the computer.

For example, for an acquired decimal value of 17, the binary equivalent is 0001 0001. This binary value indicates that Bits 4 and 0 of the Service Request Enable Register are set (see previous paragraph).

Programming example

```
10     OUTPUT 707; "*SRE?"      ! Request contents of SRER
20     ENTER 707; A$            ! Address 7001 to talk
30     PRINT A$                 ! Display value register
```

5.10.14 *STB? — status byte query

Purpose To read the contents of the Status Byte Register.

Format ***STB?**

Description The *STB? query command is used to acquire the value (in decimal) of the Status Byte Register. The Status Byte Register is shown in Figure 5-16. The binary equivalent of the decimal value determines which bits in the register are set. The set bits in this register define the operating status of the Model 7001.

When the *STB? query command is sent, the decimal value is placed in the Output Queue. When the Model 7001 is addressed to talk, the value is sent from the Output Queue to the computer.

All bits, except Bit 6, in this register are set by other event registers and queues. Bit 6 sets when one or more enabled conditions occur.

The *STB? query command does not clear the status byte register. This register can only be cleared by clearing the related registers and queues. Register and queue structure are explained in paragraph 5.6.

For example, for an acquired decimal value of 48, the binary equivalent is 00110000. This binary value indicates that Bits 4 and 5 of the Status Byte Register are set.

The bits of the Status Byte Register are described as follows:

Bit 0 — Not used.

Bit 1 — Not used.

Bit 2, Error Available (EAV) — Set bit indicates that an error message is present in the Error Queue. The error message can be read using one of the following SCPI commands:

:SYSTem:ERRor?
:STATus:QUEue?

See paragraphs 5.17 and 5.16 for details.

Bit 3,Questionable Summary Bit (QSB) — Always zero (Questionable events not used by Model 7001).

Bit 4, Message Available (MAV) — Set bit indicates that a message is present in the Output Queue. The message is sent to the computer when the Model 7001 is addressed to talk.

Bit 5, Event Summary Bit (ESB) — Set bit indicates that an enabled standard event has occurred. The event can be identified by reading the Standard Event Status Register using the *ESE? query command (see paragraph 5.10.2).

Bit 6, Master Summary Status (MSS) / Request Service (RQS) — Set bit indicates that one or more enabled conditions have occurred to generate a service request (SRQ). Note that the IEEE-488.1 standard designates Bit 6 as the RQS bit and is read by performing a Serial Poll.

Bit 7, Operation Summary Bit (OSB) — Set bit indicates that an enabled operation event has occurred. The event can be identified by reading the Operation Event Status Register using the following SCPI command structure:

:STATus:OPERation?

See paragraph 5.16 for details.

Programming example

```
10    OUTPUT 707; "*SRE?"     ! Request contents of register
20    ENTER 707; A$           ! Address 7001 to talk
30    PRINT A$                ! Display value of register
40    END
```

Bit Position	B7	B6	B5	B4	B3	B2	B1	B0
Event	OSB	MSS, RQS	ESB	MAV	QSB	EAV	—	—
Decimal Weighting	128 (2^7)	64 (2^6)	32 (2^5)	16 (2^4)	8 (2^3)	4 (2^2)	—	—
Value	0/1	0/1	0/1	0/1	0/1	0/1	—	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Events : OSB = Operation Summary Bit
MSS = Master Summary Status
RQS = Request Service
ESB = Event Summary Bit
MAV = Message Available
QSB = Questionable Summary Bit
EAV = Error Available

Figure 5-16
Status Byte Register

5.10.15 *TRG — trigger

Purpose To issue a GPIB trigger to the Model 7001.

Format ***TRG**

Description The *TRG command is used to issue a GPIB trigger to the Model 7001. It has the same effect as a group execute trigger (GET). The *TRG command is an overlapped command, while GET is not. See *OPC, *OPC? and *WAI for more information.

The *TRG command is used as an arm, scan and/or channel event to control the scan cycle. The Model 7001 will react to this trigger if GPIB is the programmed control source. The control source is programmed from the SCPI :TRIGger Subsystem (see paragraph 5.18).

Programming example

```
OUTPUT 707; “*TRG”                ! Trigger 7001
```

5.10.16 *TST? — self-test query

Purpose To run the self-tests and acquire the results.

Format ***TST?**

Description The *TST? query command is used to perform a checksum test on ROM and place the coded result (0 or 1) in the Output Queue. When the Model 7001 is addressed to talk, the coded result is sent from the Output Queue to the computer.

A returned value of zero (0) indicates that the test passed, and a value of one (1) indicates that the test has failed.

Programming example

```
10    OUTPUT 707; "*TST?"     ! Run and request test result
20    ENTER 707; A$           ! Address 7001 to talk
30    PRINT A$                ! Display coded result
```

5.10.17 *WAI — wait-to-continue

Purpose

To prevent the execution of further commands until all previous overlapped commands are completed.

Format

***WAI**

Description

There are two types of device commands; Sequential commands and overlapped commands. A Sequential command is a command whose operations are allowed to finish before the next command is executed. An overlapped command is a command that allows the execution of subsequent commands while device operations of the overlapped command are still in progress. The *WAI command is used to hold off the execution of subsequent commands until the device operations of all previous overlapped command are finished. The *WAI command is not needed for Sequential commands.

NOTE

See *OPC, *OPC? and *TRG for more information.

The :INIT command takes the Model 7001 out of the idle state to enable the scan function. The device operations of the :INIT command are not considered complete until the Model 7001 goes back into the idle state. Typically, this occurs when all programmed scan operations are completed. By sending the *WAI command after the :INIT command, all subsequent commands will not execute until the Model 7001 goes back into the idle state.

The *TRG command issues a bus trigger which could be used to provide the arm, scan and channel events for the Trigger Model. By sending the *WAI command after the *TRG command, subsequent commands will not be executed until the pointer for the Trigger Model has finished moving in response to *TRG and has settled at its next state.

Programming example

```
10    OUTPUT 707; “:open   all”
20    OUTPUT 707; “*RST”
30    OUTPUT 707; “:scan   (@ 1!1:1!10)”
40    OUTPUT 707; “:trig:coun:auto   on”
50    OUTPUT 707; “:trig:del   0.5”
60    OUTPUT 707; “:init”
70    OUTPUT 707; “*WAI”
80    OUTPUT 707; “:clos   (@ 1!11:1!20)”
90    END
```

Line 10	Opens all channels.
Line 20	Selects default configuration (see Table 5-5).
Line 30	Defines scan list (channels 1 through 10).
Line 40	Enables automatic scan-list-length for channel count.
Line 50	Sets a 0.5 second delay between each channel.
Line 60	Starts the scan (takes 7001 out of idle state).

Line 70 Wait until scan is finished.
Line 80 Close channels 11 through 20.

When the above program is run, channels 1 through 10 will be scanned and then, at the end of the scan, channels 11 through 20 will close. Without the *WAI command (Line 70), channels 11 through 20 will close at the same time that the scan starts.

SCPI command subsystems

SCPI commands are categorized into subsystems. The subsystems are presented in alphabetical order as follows:

5.11	**:DISPlay subsystem** — Explains the commands used to control user defined text messages.
5.12	**:OUTPut subsystem** — Explains the commands used to program the polarity (active-high or active-low) of the digital output port bits.
5.13	**:ROUTe subsystem** — Covers commands used to open and close channels, define a scan list, specify restricted (forbidden) channels, and enable/disable Single Channel and Card Pair. Also covered are slot configuration commands used to program the relay settling time, pole-mode and card type of each slot. Finally, memory commands used to store (save) and recall channel patterns are explained here.
5.14	**Sense subsystems** — Explains the command used to read the digital input port of the Model 7001 (and digital cards).
5.15	**:SOURce subsystem** — Covers the commands used to set the state (0 or 1) of the digital output port bits.
5.16	**:STATus subsystem** — Covers the commands used to control the status registers of the Model 7001.
5.17	**:SYSTem subsystem** — Covers miscellaneous commands used to read the software revision level of the Model 7001, read the error queue, and set the power-on setup configuration.
5.18	**Trigger subsystem** — Covers commands used to scan.

5.11 :DISPlay subsystem

The display subsystem controls the display circuitry of the Model 7001 and is summarized in Table 5-6.

Table 5-6
DISPlay command summary

Command	Description
:DISPlay	
[:WINDow[1]]	Path to locate message to top display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message "a" using up to 20 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:WINDow2	Path to locate message to bottom display.
:TEXT	Path to control user text messages.
:DATA <a>	Define ASCII message "a" using up to 32 characters.
:DATA?	Query text message.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message mode.
:STATe?	Query text message mode (0 or 1).
:WINDow3	Path to control LED Graticule.
:GRATicule <b>	Enable (1 or ON) or disable (0 or OFF) the LED Graticule.
:SMESsage <b>	Enable (1 or ON) or disable (0 or OFF) status message mode.
:SMESsage?	Query status message mode (0 or 1).
:ENABle <b>	Turn on (1 or ON) or turn off (0 or OFF) the front panel display circuitry.
:ENABle?	Query state of the display (0 or 1).

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

:TEXT commands

:DATA <a>

:DISPlay[:WINDow[1]]:TEXT:DATA <a>	Define message for top display
:DISPlay:WINDow2:TEXT:DATA <a>	Define message for bottom display

Parameter <a> = ASCII characters for message.

Short-form formats

String	:disp:text:data 'aa...a'
	:disp:wind2:text:data 'aa...a'

Indefinite block	:disp:text:data #0aa...a :disp:wind2:text:data #0aa...a
Definite block	:disp:text:data #XYaa...a :disp:wind2:text:data #XYaa...a

where; Y = number of characters in message:
Up to 20 for top display.
Up to 32 for bottom display.
X = number of digits that make up Y (1 or 2).

Defaults

Power-up	Null string
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:DATA?	Query the defined text message
Short-form formats:	:disp:text:data? :disp:wind2:text:data?
Response message:	User defined text message

Description

These commands define the text messages that you wish to display. The message can be as long as 20 characters for the top display, and up to 32 characters for the bottom display. A space is counted as a character. Excess message characters (over 20 and 32 respectively) will cause error.

A string message must be enclosed in single quotes or double quotes. Both of the following sting messages are valid:

'Keithley Model 7001' or "Keithley Model 7001"

An indefinite block message must be the only command in the program message or the last command in the program message. If you include a command after an indefinite block message (on the same line), it will be treated as part of the message and will be displayed instead of executed.

Programming example

```
10    OUTPUT 707; ":disp:text:data   'Keithley Model 7001'; data?"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10	Defines the user defined message for the top display, and then queries the defined message.
Line 20	Addresses the 7001 to talk.
Line 30	Displays (on the CRT) the user defined message.

:STATe <b>

:DISPlay[:WINDow[1]]:TEXT:STATe <b>	Control message; top display
:DISPlay:WINDow2:TEXT:STATe <b>	Control message; bottom display

Parameters

<b>	= 0 or OFF	Disable text message for specified display
	= 1 or ON	Enable text message for specified display

Short-form formats

:disp:text:stat <b>
:disp:wind2:text:stat <b>

Defaults

Power-up	OFF
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:STATe?	Query state of message mode for specified display
Short-form formats:	:disp:text:stat? :disp:wind2:text:stat?
Response message:	1 (on) or 0 (off)

Description

These commands enable and disable the text message modes. When enabled, a defined message (see previous command) will be shown on the top or bottom portion of the display. When disabled, the message will be removed from the display, and the Model 7001 will resume normal operation.

A user defined text message remains displayed only as long as the instrument is in remote. Taking the instrument out of remote (by pressing the LOCAL key or sending LOCAL 707), cancels the message and disables the text message mode.

Programming example

```
10  OUTPUT 707; ":disp:text:stat   on; stat?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10	Displays a defined user message (see previous command) on the top display, and then queries the state (on or off) of the display.
Line 20	Addresses the 7001 to talk.
Line 30	Displays (on the CRT) the state of the message mode (1; on).

:WINDow3 Command

:GRATicule <b>

:DISPlay:WINDow3:GRATicule <b> Control LED Graticule

Parameters

<b>	= 0 or OFF	Disable LED Graticule
	= 1 or ON	Enable LED Graticule

Short-form formats

:disp:wind3:grat <b>

Defaults

Power-up	ON
*RST	ON
:SYSTem:PRESet	ON

Query command

:GRATicule?	Query state of LED Graticule
Short-form format:	:disp:wind3:grat?
Response message:	1 (on) or 0 (off)

Description

This command is used to control the LED Graticule. When enabled, all available channels are denoted by channel LEDs that are turned on (dimly lit or brightly lit). Channels not available are denoted by channel LEDs that are turned off.

Contrast between on and off LEDs can be increased by disabling the LED Graticule. When disabled, there is no dimply lit state for the LEDs. An LED that would normally be dimly lit is instead turned completely off. Each LED is either off or brightly lit.

NOTE

If the main CPU firmware is not compatible with the LED display firmware, the following error will occur when trying to disable the LED Graticule.

ERROR:ID CODE = +551
Incorrect software revision

If this error should occur, contact Keithley to resolve the firmware incompatibility.

Programming example

```
10  OUTPUT 707; ":disp:wind3:grat   on; grat?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Disables the LED Graticule and then queries the state of the LED Graticule.
Line 20 Addresses the 7001 to talk.
Line 30 Displays (on the CRT) the state of the LED Graticule (0; off).

:SMESsage <b>

:DISPlay:SMESsage <b> Control status messages

Parameters

<b>	= 0 or OFF	Disable status messages
	= 1 or ON	Enable status messages

Short-form formats

:disp:smes <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	OFF

Query command

:SMESsage?	Query state of status message mode
Short-form formats:	:disp:smes?
Response message:	1 (on) or 0 (off)

Description

This command is used to enable/disable the status message mode for the Model 7001. The status message mode is a diagnostic tool that provides real-time messages that relate to the current operating state of the instrument. When the status message mode is disabled, only the error events (EE) in Table 4-1 will be reported to the display.

Programming example

```
10    OUTPUT 707; ":disp:smes   on; smes?"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10 Enables the status message mode, and then queries the state of the message mode.
Line 20 Addresses the 7001 to talk.
Line 30 Displays the state of the status message mode (1; on).

:ENABle <b>

:DISPlay:ENABle <b> Control display circuitry

Parameters

<b>	= 0 or OFF	Disable display circuitry
	= 1 or ON	Enable display circuitry

Short-form formats

:disp:enab <b>

Defaults

Power-up	ON
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:ENABle?	Query state of display
Short-form formats:	:disp:enab?
Response message:	1 (on) or 0 (off)

Description

This command is used to enable and disable the front panel display circuitry. Disabling the display circuitry allows the instrument to operate at a higher speed. While disabled, the display will be frozen with the following message:

FRONT PANEL DISABLED
Press LOCAL to resume.

As reported by the message, all front panel controls (except LOCAL) will be disabled. Normal display operation can be resumed by using the :ENABle command to enable the display or by putting the Model 7001 into local.

Programming example

```
10    OUTPUT 707; ":disp:enab   off; enab?"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10 Disables the display, and then queries the state of the display.
Line 20 Addresses the 7001 to talk.
Line 30 Displays (on the CRT) the programmed state of the display (0; off).

5.12 :OUTPut subsystem

The OUTPut subsystem is used to set polarities for the digital output port. Commands in this subsystem are summarized in Table 5-7.

Table 5-7
OUTPut command summary

Command	Description
:OUTPut	
:TTL[1]	Path to set polarity of digital output line 1:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 1.
:TTL2	Path to set polarity of digital output line 2:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 2.
:TTL3	Path to set polarity of digital output line 3:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 3.
:TTL4	Path to set polarity of digital output line 4:
:LSENse <name>	Select polarity; active high (AHIGh) or active low (ALOW).
:LSENse?	Query polarity of line 4.

Notes:

1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

:LSENse <name>

:OUTPut:TTL[1]:LSENse <name>	Set polarity of line #1
:OUTPut:TTL2:LSENse <name>	Set polarity of line #2
:OUTPut:TTL3:LSENse <name>	Set polarity of line #3
:OUTPut:TTL4:LSENse <name>	Set polarity of line #4

Parameters

<name> = AHIGh Set polarity of specified line to active high.
= ALOW Set polarity of specified line to active low.

Short-form formats

:outp:ttl:lsen <name>
:outp:ttl2:lsen <name>
:outp:ttl3:lsen <name>
:outp:ttl4:lsen <name>

Defaults

Power-up	Active high
*RST	No effect
:SYSTem:PRESet	No effect

Query command	:LSENse?	Query polarity of specified line
	Short-form formats:	:outp:ttl:lsen? :outp:ttl2:lsen? :outp:ttl3:lsen? :outp:ttl4:lsen?
	Response message:	AHIG or ALOW

Description

These commands are used to set the polarity of the digital output lines. When set for active high (AHIGh) polarity, the specified output line is true (ON) when the output level is high. The output line is false (OFF) when the output level is low.

When set for active low (ALOW) polarity, the output line is true (ON) when the output level is low. The output line is false (OFF) when the output level is high.

Programming example

```
10     OUTPUT 707; ":outp:ttl:lsen   alow; lsen?"
20     ENTER 707; A$
30     PRINT A$
40     END
```

Line 10	Sets the polarity of line #1 to active low.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the polarity of line #1 (ALOW).

5.13 [:ROUTe] subsystem

The ROUTe subsystem is used to control signal routing through the switch system and is summarized in Table 5-8. The brackets indicate that :ROUTe is optional and need not be included in the command message.

Table 5-8
ROUTe command summary

Command	Description	Reference
[:ROUTe]		
:CLOSe <list>	Close specified channels.	5.13.1
:STATe?	Query list of closed channels.	
:CLOSe? <list>	Query state of specified channels (1 = closed, 0 = open).	
:OPEN <list>|ALL	Open specified (or all) channels.	5.13.2
:OPEN? <list>	Query state of specified channels (1 = open, 0 = closed).	
:SCAN <list>	Define scan list.	5.13.3
:POINts?	Query number of channels in scan list.	
:SCAN?	Query scan list.	
:FCHannels <list>	Specify channels that cannot be closed.	5.13.4
:FCHannels?	Query channels that cannot be closed.	
:CONFigure	Configuration command path:	
:BBMake <b>	Enable (1 or ON) or Disable (0 or OFF) Break-Before-Make switching.	5.13.5
:BBMake?	Query Break-Before-Make.	
:SCHannel <b>	ENable (1 or ON) or Disable (0 or OFF) Single Channel.	5.13.6
:SCHannel?	Query Single Channel.	
:CPAir <b>	Enable (1 or ON) or Disable (0 or OFF) Card Pair.	5.13.7
:CPAir?	Query Card Pair.	
:SLOTX	Path to configure SLOT X (X = [1] or 2):	
:CTYPe <name>	Assign card ID number for specified slot.	5.13.8
:CTYPe?	Query card ID number for specified slot.	
:POLE <NRf>	Select pole mode (1, 2 or 4) for specified slot.	5.13.9
:POLE?	Query pole mode for specified slot.	
:STIMe <n>	Specify delay (0 to 99999.999 sec) for specified slot.	5.13.10
:STIMe?	Query delay for specified slot.	
:MEMory	Path to program memory:	
:SAVE M<num>	Saves channel pattern at memory location (1-100).	5.13.11
:RECall M<num>	Recalls channel pattern from memory location (1-100).	5.13.12

Notes:

1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least on space is required between a command word and the parameters.

5.13.1 :CLOSe <list>

[:ROUTe]:CLOSe <list> Close specified channels

Parameter

<list> = (@ chanlist)

where; chanlist is the specified list of channels (channel list) to be closed.

Short-form formats

:clos (@ chanlist)

Defaults

Power-up	All channels open
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:CLOSe? <list>	Query state of specified channels.
Short-form formats:	:clos? (@ chanlist)
Response message:	1 = specified channel(s) closed. 0 = specified channel(s) not closed.

Description

The :CLOSe command is used to close the channel(s) specified by the channel list (chanlist) in the <list> parameter. The following examples demonstrate various forms for expressing channel entries for a chanlist.

Chanlist

1!2!4	Single channel (Slot 1, Row 2, Column 4).
2!36	Single channel (Slot 2, Channel 36).
1!6, 1!18, 2!3!6	Multiple channels separated by commas.
1!2:1!10	Range of channels (2 through 10).
1!2:1!10, 2!3!6	Range entry and single entry separated by commas.
1!30:1!40, 2!1:2!10	Range of multiplex channels (last 10 channels on card 1, first 10 channels on card 2).
1!4!1:1!4!10, 2!1!1:2!4!10	Range of matrix channels (10 columns of row 4 on card 1, 10 columns of row 1 on card 2).
M36	Channel pattern stored at memory location M36.

The :CLOSe? <list> query command is used to determine the state (closed or not closed) of each specified channel. After sending this command and addressing the Model 7001 to talk, the values for the specified channels will be sent to the computer. A value of "1" indicates that the channel is closed, and a "0" indicates that the channel is not closed (open).

For example, assume channels 2, 3 and 6 are closed and the following query command is sent:

:clos? (@ 1:10)

After addressing the Model 7001 to talk, the following response message will be sent to the computer:

```
0,1,1,0,0,1,0,0,0,0
```

Programming example

This example assumes that all channels are initially open.

```
10    OUTPUT 707; ":clos   (@ 1!2, 1!3, 1!6); clos?   (@ 1!1:1!10)"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10	Closes channels 2, 3 and 6, and then queries all ten channels.
Line 20	Addresses the Model 7001 to talk.
Line 30	Displays the state of all ten channels (0,1,1,0,0,1, 0,0,0,0).

:STATe?

[:ROUTe]:CLOSe:STATe? Query closed channels

Short-form formats

:clos:stat?

Description

This query command is used to request the channels that are currently closed. For example if channels 1!2!3 and 2!36 are closed, the following message will be sent to the computer after sending this command and addressing the Model 7001 to talk:

```
(@1!2!3, 2!36)
```

Programming example

```
10    OUTPUT 707; ":clos   (@ 1!1, 1!5:1!10); clos:stat?"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10	Two commands on this line. CLOSe closes the listed channels and STATe? queries the list of closed channels.
Line 20	Addresses the Model 7001 to talk.
Line 30	Displays (on the CRT) the list of closed channels.

5.13.2 :OPEN <list> | ALL

[:ROUTe]:OPEN <list>|ALL Open specified (or all) channels

Parameters

<list> = (@ chanlist)	Open listed channels
ALL	Open all channels

where; chanlist is the specified list of channels (channel list) to be opened.

Short-form formats

:open (@ chanlist)
:open all

Defaults

Power-up	All channels open
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:OPEN? <list>	Query state of specified channels.
Short-form formats:	:open? (@ chanlist)
Response message:	1 = specified channel(s) open. 0 = specified channel(s) not open.

Description

The :OPEN command is used to open one or more channels. The <list> parameter is used to define a channel list (chanlist) the specifies which channels to open. The ALL parameter is used to simply open all channels.

The following examples demonstrate various forms for expressing channel entries for a chanlist.

Chanlist	
1!2!4	Single channel (Slot 1, Row 2, Column 4).
2!36	Single channel (Slot 2, Channel 36).
1!6, 1!18, 2!3!6	Multiple channels separated by commas.
1!2:1!10	Range of channels (2 through 10).
1!2:1!10, 2!3!6	Range entry and single entry separated by commas.
1!30:1!40, 2!1:2!10	Range of multiplex channels (last 10 channels on card 1, first 10 channels on card 2).
1!4!1:1!4!10, 2!1!1:2!1!10	Range of matrix channels (10 columns of row 4 on card 1, 10 columns of row 1 on card 2).
M36	Channel pattern stored at memory location M36.

The :OPEN? <list> query command is used to determine the state (open or not open) of each specified channel. After sending this command and addressing the Model 7001 to talk, the values for the specified channels will be sent to the computer. A value of “1” indicates that the channel is open, and a “0” indicates that the channel is not open (closed).

For example, assume channels 2, 3 and 6 are open and the following query command is sent:

:open? (@ 1:10)

After addressing the Model 7001 to talk, the following response message will be sent to the computer:

0,1,1,0,0,1,0,0,0,0

Programming example

This example assumes that all channels are closed.

```
10     OUTPUT 707; “:open  (@ 1!2, 1!3, 1!6); open?  (@ 1!1:1!10)”
20     ENTER 707; A$
30     PRINT A$
40     END
```

Line 10 Open channels 2, 3 and 6, and then queries all ten channels.
Line 20 Addresses the Model 7001 to talk.
Line 30 Displays the state of all ten channels (0,1,1,0,0,1, 0,0,0,0).

5.13.3 :SCAN <list>

[:ROUTe]:SCAN <list> Define scan list

Parameter

<list> = (@ scanlist)

where; scanlist is the specified list of channels (scan list) to be scanned.

Short-form formats

:scan (@ scanlist)

Defaults

Power-up	Last defined scan list
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:SCAN?	Query scan list
Short-form formats:	:scan?
Response message:	Currently defined scan list

Description

The :SCAN command is used to define a scan list. The list of channels to be scanned (scanlist) are included in the <list> parameter.

The following examples demonstrate various forms for expressing channel entries for a scanlist.

Scanlist	
1!6, 1!18, 2!3!6	Multiple channels separated by commas.
1!2:1!10	Range of channels (2 through 10).
1!2:1!10, 2!3!6	Range entry and single entry separated by commas.
1!30:1!40, 2!1:2!10	Range of multiplex channels (last 10 channels on card 1, first 10 channels on card 2).
1!4!1:1!4!10, 2!1!1:2!1!10	Range of matrix channels (10 columns of row 4 on card 1, 10 columns of row 1 on card 2).
M36	Channel pattern stored at memory location M36.

The Scan List is not lost (cleared) after the instrument is turned off. However, the Scan List is cleared if a channel in the Scan List becomes unavailable or restricted.

:POINts?

[:ROUTe]:SCAN:POINts? Query scan list length

Short-form formats :scan:poin?

Description This query command is used to request the number of channels in the scan list. A channel pattern (i.e. M1) in the scan list is counted as one channel. For example, assume the following scan list:

(@ 1!1:1!5, 1!10, M2)

After the POINt? command is sent and the Model 7001 is addressed to talk, the following message will be sent to the computer:

7

The “7” indicates that the scan list length is seven channels.

Programming example

```
10    OUTPUT 707; “:scan   (@1!2, 1!4); scan:poin?”
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10 :SCAN defines the scan list and POINts? queries the number of channels in the scan list.

Line 20 Addresses the 7001 to talk.

Line 30 Displays (on the CRT) the number of channels (2) in the scan list.

5.13.4 :FCHannels <list>

[:ROUTe]:FCHannels <list> Define “forbidden” channel list

Parameter

<list> = (@ forblist)

where; forblist is the specified list of “forbidden” channels that cannot be closed.

Short-form formats

:fch (@ forblist)

Defaults

Power-up	Last defined “forbidden” channel list
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:FCHannels?	Query “forbidden” channel list
Short-form formats:	:fch?
Response message:	List of “forbidden” channels

Description

The :FCHannels <list> command is used to define a list of channels that cannot be closed. The following examples demonstrate various forms for expressing a forblist:

Forblist	
1!1	Single channel (Slot 1, Channel 1).
1!6, 1!18, 2!3!6	Channels separated by commas.
1!2:1!10	Range of channels (2 through 10).
1!2:1!10, 1!20	Range entry and single entry separated by commas.
M36	Channel pattern stored at memory location M36.

A “forbidden” channel list can be cancelled by sending an empty forblist as follows:

```
:fch (@)
```

If you specify a channel to be restricted and it is already included in the Scan List and/or a Channel Pattern, then the entire Scan List and/or Channel Pattern is cleared (lost).

Programming example

```
10    OUTPUT 707; “:fch   (@ 1!1, 1!4); fch?”
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10	Define the “forbidden” channel list and query the the list.
Line 20	Address the Model 7001 to talk.
Line 30	Display the list.

:CONFigure Commands:

5.13.5 :BBMake <b>

[:ROUTe]:CONFigure:BBMake <b> Control Break-Before-Make switching

Parameters

<b>	= 0 or OFF	Disable Break-Before-Make switching
	= 1 or ON	Enable Break-Before-Make switching

Defaults

Power-up	Saved power-on setup
*RST	On
:SYSTem:PRESet	On

Query command

:BBMake?	Query Break-Before-Make
Short-form formats:	:conf:bbm?
Response message:	1 (on) or 0 (off)

Description

When scanning, recalling saved channel patterns or in the Single Channel mode, enabling Break-Before-Make will assure that the currently closed channel will open before the next channel closes.

When Break-Before-Make is disabled, the assurance that the current channel will open before the next channel closes is lost. In other words, two channels could momentarily be closed at the same time. An advantage to disabling Break-Before-Make is an increase in speed.

Programming example

```
10    OUTPUT 707; ":conf:bbm  off; bbm?"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10 Disables Break-Before-Make and then queries its status.
Line 20 Addresses the 7001 to talk.
Line 30 Displays the status of Break-Before-Make (0; off).

5.13.6 :SCHannel <b>

[:ROUTe]:CONFigure:SCHannel <b> Control Single Channel mode

Parameters

<b>	= 0 or OFF	Disable Single Channel mode.
	= 1 or ON	Enable Single Channel mode.

Short-form formats

:conf:sch <b>

Defaults

Power-up	Saved power-on setup
*RST	Off
:SYSTem:PRESet	Off

Query command

:SCHannel?	Query status of Single Channel
Short-form formats:	:conf:sch?
Response message:	0 (off) or 1 (on)

Description

The Single Channel mode (when enabled) is used to prevent more than one channel from closing at a time. When a single channel is closed, the previous closed channel will open. This ensures that even with random channel closures, only one channel can be closed at a time. Toggling the Single Channel mode from off to on causes all channels to open. For complete details on Single Channel, see Section 4.

Programming example

```
10    OUTPUT 707; ":conf:sch   on; sch?"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10	Enables Single Channel and then queries its status.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the status of Single Channel (1; on).

5.13.7 :CPAir <b>

[:ROUTe]:CONFigure:CPAir <b> Control Card Pair

Parameters

<b> = 0 or OFF Disable Card Pair.
= 1 or ON Enable Card Pair.

Short-form format

:conf:cpa <b>

Defaults

Power-up	Saved power-on setup
*RST	Disables Card Pair
:SYSTem:PRESet	Disables Card Pair

Query command

:CPAir?	Query status of Card Pair
Short-form format:	:conf:cpa?
Response message:	0 (off) or 1 (on)

Description

With Card Pair enabled, the corresponding channels of the two slots are controlled concurrently. For example, when channel 5 of CARD 1 (Slot 1) is closed, channel 5 of CARD 2 (Slot 2) is also closed.

Card Pair can only be enabled for similar type cards. For example, you will not be able to enable Card pair if a multiplexer card is installed in Slot 1 and a matrix card is installed in Slot 0.

If enabling Card Pair adds a restricted channel to the Scan List and/or a Channel Pattern, then the entire Scan List and/or Channel Pattern is cleared (lost).

Programming example

```
10    OUTPUT 707; ":conf:cpa   on; cpa?"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10	Enables Card Pair and then queries its status.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the status of Card Pair (1; on).

5.13.8 :CTYPe <name>

[:ROUTe]:CONFigure:SLOT[1]:CTYPe <name>	Assign card ID number for SLOT 1
[:ROUTe]:CONFigure:SLOT2:CTYPe <name>	Assign card ID number for SLOT 2

Parameters

<name> = C7052
= C7053
= C7054
= C7056
= C7057
= C7058
= C7059
= C7061
= C7062
= C7063
= C7064
= C7065
= C7066

<name> = C7067
= C7152
= C7153
= C7154
= C7156
= C7158
= C7164
= C7166
= C7168
= C7169
= C7402
= C9990
= C9991

Short-form formats

:conf:slot:ctyp <name>
:conf:slot2:ctyp <name>

Defaults

Power-up	Each slot uses the last programmed type, or a 701X card type that is detected.
*RST	No effect
:SYSTem:PRESet	No effect

Query command

:CYTPe?	Query card ID assignment for specified slot.
Short-form formats:	:conf:slot:ctyp? :conf:slot2:ctyp?
Response message:	Assigned card ID (e.g. C7156)

Description

After installing a non-701X series card in a mainframe slot, use the :CYTPe command to assign the ID (identification) number (type) for that slot. For example, if a Model 7156 card is installed in Slot 1, send type parameter C7156 with the command.

Type C9990 or C9991 can be used to assign a slot as a card simulator. By assigning C9990, the instrument will operate as if a 40 channel switch card were installed in the specified slot. By assigning C9991, the instrument will operate as if a 4 x 10 matrix were installed.

A slot assignment change could make a channel that is currently included in the Scan List and/or a Channel Pattern unavailable. The unavailable channel causes the Scan List and/or the affected Channel Pattern to clear.

Programming example

This program assumes that Slot 1 is empty.

```
10    OUTPUT 707; ":conf:slot1:ctyp   C9990; ctyp?"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10	Assigns simulator C9990 to Slot 1 and then queries the model number.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the card ID number assigned to Slot 1 (C9990).

5.13.9 :POLE <NRf>

[:ROUTe]:CONFigure:SLOT[1]:POLE <NRf>	Select pole mode for card in Slot 1
[:ROUTe]:CONFigure:SLOT2:POLE <NRf>	Select pole mode for card in Slot 2

Parameters

<NRf> = 1	Select 1-pole mode
= 2	Select 2-pole mode
= 4	Select 4-pole mode

Short-form formats

:conf:slot:pole <NRf>
:conf:slot2:pole <NRf>

Defaults

Power-up	Last selected pole mode for each slot
*RST	No effect
:SYSTem:PRESet	No effect

Query command		
	:POLE?	Query pole mode for specified slot
	Short-form formats:	:conf:slot:pole? :conf:slot2:pole?
	Response message:	1 (1-pole mode) 2 (2-pole mode) 4 (4-pole mode)

Description

Some cards have the capability to operate as more than one switch type. For example, the Model 7011 multiplexer card can be used for 40-channel, 2-pole switching, or for 20-channel, 4-pole switching.

The switch cards that have an additional pole mode capability are summarized as follows:

Pole Mode:

Card	1-Pole	2-pole	4-pole
7011	N/A	40 channels	20 channels
7056	20 channels	10 channels	N/A
7156	20 channels	10 channels	N/A

Keep in mind that the card must be wired appropriately for the selected pole mode. For more information on Pole-Mode, see Section 4 of this manual.

The factory default is the 2-pole mode for all cards. The :POLE command is used to select an alternate pole mode for the card in the specified slot. An invalid pole mode cannot be selected and will result in an error message.

Changing the pole mode for a slot could cause a channel to become unavailable. As can be seen from the above table for the Model 7011 mux card, 20 channels become unavailable when changing from 2-pole to 4-pole operation. If one or more of these unavailable channels were included in the Scan List and/or in a Channel Pattern, then the entire Scan List and/or affected Channel Pattern will be lost (cleared).

Programming example

```
10   OUTPUT 707; ":conf:slot:pole  4; pole?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10 Selects the 4-pole mode for Slot 1 and then queries the pole mode.
Line 20 Addresses the 7001 to talk.
Line 30 Displays the pole mode for Slot 1 (4).

5.13.10 :STIMe <n>

[:ROUTe]:CONFigure:SLOT[1]:STIMe <n>	Set delay for Slot 1
[:ROUTe]:CONFigure:SLOT2:STIMe <n>	Set delay for Slot 2

Parameters

<n>	= 0 to 99999.999	Settling time in seconds
	= DEFault	0 sec
	= MINimum	0 sec
	= MAXimum	99999.999 sec

Short-form formats

:conf:slot:stim <n>
:conf:slot2:stim <n>

Defaults

Power-up	0 sec
*RST	0 sec
:SYSTem:PRESet	0 sec

Query commands

:STIMe?	Query programmed delay for specified slot			
:STIMe? DEFault	Query *RST default delay			
:STIMe? MINimum	Query minimum delay			
:STIME? MAXimum	Query maximum delay			
Short-form formats:	:conf:slot:stim?		:conf:slot2:stim?	
	:conf:slot:stim?	def	:conf:slot2:stim?	def
	:conf:slot:stim?	min	:conf:slot2:stim?	min
	:conf:slot:stim?	max	:conf:slot2:stim?	max
Response message:	0 to 99999.999			

Description

An internally set relay settling time is provided to allow for switch bounce when it closes. At power-up, a settling time is automatically set based on the acquired identification information from the card. The :STIMe command allows you to increase the delay for each slot.

The delay value can be entered using the exponent form. For example, instead of sending a parameter value of 2000 (seconds), you can instead send 2E3. To cancel this delay, send this command using a parameter value of 0.

For complete information on this delay, see DELAY in Section 4.

Programming example

```
10    OUTPUT 707; “:conf:slot:stim   10; stim?”
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10	Sets a 10 second delay for Slot 1 and then queries the delay period.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the delay period (10).

:MEMory Commands:

5.13.11 :SAVE M<num>

[:ROUTe]:MEMory:SAVE M<num> Save current channel pattern at specified memory location

Parameter

<num> = a whole number from 1 to 100 Specify memory location

Short-form formats

:mem:save M<num>

Defaults

Power-up	No effect
*RST	No effect
:SYSTem PRESet	No effect

Description

This command is used to save (store) the current channel pattern at a memory location. For example, if channels 1!1, 1!6, 1!8 and 2!5 are currently closed, you can save that channel pattern to memory location 36. When M36 is later recalled or scanned, the four channels of that channel pattern will close, and all other channels will open.

Up to 100 channel patterns can be saved in memory locations 1 to 100. A channel pattern can be recalled from memory using the :RECall command.

A Channel Pattern is not lost (cleared) after the instrument is turned off. However, a Channel Pattern is cleared if a closed channel in the pattern becomes unavailable or restricted.

Programming example

```
OUTPUT 707; ":clos   (@ 1!1:1!10)"      ! Closes ch 1-10 of Slot 1
OUTPUT 707; ":mem:save   M36"           ! Saves pattern to M36
```

1st Line	Closes channels 1-10 of Slot 1.
2nd Line	Saves channel pattern to memory location 36.

5.13.12 :RECall M<num>

[:ROUTe]:MEMory:RECall M<NRf> Recall channel pattern from memory

Parameter

<num> = 1 to 100 Specify memory location

Short-form formats

:mem:rec M<num>

Description

This command is used to recall a channel pattern stored at a memory location. Channel patterns can be recalled from memory locations 1 to 100. As soon as the channel pattern is recalled, channels will immediately close and/or open as dictated by the channel pattern. The front panel channel status display will also update to reflect the channel pattern.

The Model 7001 is shipped from the factory with blank channel patterns stored in all 100 memory locations. A blank channel pattern has no closed channels. All channels for both slots will open.

Channel patterns can be stored in memory using the :SAVe command.

Programming example

```
OUTPUT 707; ":mem:rec   M24"
```

Recall channel pattern from memory location 24.

5.14 Sense Subsystems

The Sense subsystems are used to read digital input ports. The :SENSe1 Subsystem is used to read the built-in digital input lines. The :SENSe2 and :SENSe3 Subsystems are used to read the inputs of digital cards installed in slots 1 and 2 respectively.

Table 5-9
SENSe command summary

Command	Description
:SENSe[1] :TTL[1] :DATA?	 Command path to read internal input line. Read internal digital input line.
:SENSe2 :DATA? <list>	Command path: Read specified input channels for slot 1.
:SENSe3 :DATA? <list>	Command path: Read specified input channels for slot 2.

Notes:
1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is requred between a command word and the parameter.

:SENSe[1] Subsystem

:TTL[1]:DATA?

:SENSe[1]:TTL[1]:DATA?	Read internal input port

Short-form formats

:sens:ttl:data?

Description

This command is used to read the single line of the digital input port. After sending this command and addressing the Model 7001 to talk, a value indicating the status of the port will be sent to the computer.

A value of “1” indicates that the input port is high (ON), and a value of “0” indicates that the port is low (OFF).

Programming example

```
10    OUTPUT 707; “:sens:ttl:data?”
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10 Read the input port.
Line 20 Addresses the 7001 to talk.
Line 30 Displays the status of the input port (0 or 1).

:SENSe2 and :SENSe3 Subsystems

:DATA? <list>

:SENSe2:DATA? <list> Read specified inputs of slot 1
:SENSe3:DATA? <list> Read specified inputs of slot 2

Parameter

<list> = (@ chanlist)

where: chanlist is the specified list of input channels to be read.

Short-form formats

:sens2:data?

:sens3:data?

Description

These commands are used to read the specified inputs of digital I/O cards installed in the slots of the mainframe. After sending one of these commands and addressing the Model 7001 to talk, a value indicating the status of each specified input channel is sent to the computer. A value of "1" indicates that the input channel is high (on) and a value of "0" indicates that the input channel is low (off).

The conventional form for the <list> parameter includes the slot and input channel number. However, for these commands, you do not need to include the slot number. For example, you can send either of the following two commands to read input channel 23 of slot 2:

:SENSe3:DATA? (@2!23) or :SENSe3:DATA? (@23)

After the mainframe is addressed to talk, the response message will indicate the state of the input channel 23 of slot 2.

In another example, you can send either of the following two commands to read all 40 input channels of an I/O card in slot 2:

:SENSe3:DATA? (@ 1!1:1!40) or :SENSe3:DATA? (@ 1:40)

The response message will include a "0" (off) or "1" (on) for each of the 40 input channels (i.e. "0, 0, 0, 1, 0 ... 1").

You can send up to two of the query commands in the same program message. For example, the following program message is valid:

:sense2:data? <list>; :sens3:data? <list>

Sending three or more of these queries in the same program message will cause the Model 7001 to lock up and will require that you send an IFC and then a DCL to restore operation.

Send one of these query commands for a slot which does not have an I/O card installed will result in the following error message:

ERROR: ID CODE = -241
Hardware missing

Programming example

```
10    OUTPUT 707; ":sens3:data? (@36)"
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10 Reads input channel 36 of slot 2.
Line 20 Addresses the mainframe to talk.
Line 30 Displays the status of channel 36.

5.15 :SOURce Subsystem

This subsystem is used to set the logic level (true or false) of each digital output line. The commands for this subsystem are summarized in Table 5-10.

Table 5-10
SOURce command summary

Command	Description
:SOURce	
:TTL[1]	Digital output line #1.
[:LEVel] <b>	Set line true (1 or ON) or false (0 or OFF)
[:LEVel]?	Query state of digital output line.
:TTL2	Digital output line #2.
[:LEVel] <b>	Set line true (1 or ON) or false (0 or OFF)
[:LEVel]?	Query state of digital output line.
:TTL3	Digital output line #3.
[:LEVel] <b>	Set line true (1 or ON) or false (0 or OFF)
[:LEVel]?	Query state of digital output line.
:TTL4	Digital output line #4.
[:LEVel] <b>	Set line true (1 or ON) or false (0 or OFF)
[:LEVel]?	Query state of digital output line.

Notes:

1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

[:LEVel] <b>

:SOURce:TTL[1]:[LEVel] <b>	Control digital output line #1
:SOURce:TTL2:[LEVel] <b>	Control digital output line #2
:SOURce:TTL3:[LEVel] <b>	Control digital output line #3
:SOURce:TTL4:[LEVel] <b>	Control digital output line #4

Parameters

<b>	= 1 or ON	Set output line true
	= 0 or OFF	Set output line false

Short-form formats

:sour:ttl <b>
:sour:ttl2 <b>
:sour:ttl3 <b>
:sour:ttl4 <b>

Defaults

Power-up	OFF (all lines)
*RST	No effect
:SYSTem:PRESet	No effect

Query command

[:LEVel]?	Query logic level of specified line
Shortform formats:	:sour:ttl? :sour:ttl2? :sour:ttl3? :sour:ttl4?
Response message:	0 (false) or 1 (true)

Description

These commands are used to set the logic levels for the digital output port. The actual level (high or low) of a digital output line depends on its programmed polarity (see OUTPut Subsystem). If the polarity of a line is active-high, then that line will be high when it is set to be true (1 or ON), and low when it is set to be false (0 or OFF). Conversely, if the polarity is active-low, the line will be low when it is set to be true, and high when it is set to be false.

Programming example

```
10    OUTPUT 707; “:sour:ttl   on; ttl?”
20    ENTER 707; A$
30    PRINT A$
40    END
```

Line 10 Sets output line #1 to true, and then queries the state of the output line.
Line 20 Addresses the 7001 to talk.
Line 30 Displays the state of output line #1 (1; on).

5.16 :STATus Subsystem

The status subsystem is used to control the status registers of the Model 7001. These registers and the overall status structure are explained in paragraph 5.6.

The commands in this subsystem are summarized in Table 5-11.

Table 5-11
STATus command summary

Command	Description	Reference
:STATus		
:OPERation	Path to control operation event registers:	
[:EVENt]?	Query event register.	5.16.1
:ENABle <NRf>	Program the enable register.	5.16.2
:ENABle?	Query enable register.	
:PTRansition <NRf>	Program the positive transition register.	5.16.3
:PTRansition?	Query positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	5.16.4
:NTRansition?	Query negative transition register.	
:CONDition?	Query condition register.	5.16.5
:ARM	Path to control arm event registers:	
[:EVENt]?	Query event register.	5.16.1
:ENABle <NRf>	Program the enable register.	5.16.2
:ENABle?	Query enable register.	
:PTRansition <NRf>	Program the positive transition register.	5.16.3
:PTRansition?	Query positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	5.16.4
:NTRansition?	Query negative transition register.	
:CONDition?	Query condition register.	5.16.5
:SEQuence	Path to control the sequence event registers:	
[:EVENt]?	Query event register.	5.16.1
:ENABle <NRf>	Program the enable register.	5.16.2
:ENABle?	Query enable register.	
:PTRansition <NRf>	Program the positive transition register.	5.16.3
:PTRansition?	Query positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	5.16.4
:NTRansition?	Query negative transition register.	
:CONDition?	Query condition register.	5.16.5
:TRIGger	Path to control trigger event registers:	
[:EVENt]?	Query event register.	5.16.1
:ENABle <NRf>	Program the enable register.	5.16.2
:ENABle?	Query enable register.	
:PTRansition <NRf>	Program the positive transition register.	5.16.3
:PTRansition?	Query positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	5.16.4
:NTRansition?	Query negative transition register.	
:CONDition?	Query condition register.	5.16.5
:QUEStionable	Path to control questionable event registers:	
[:EVENt]?	Query the event register.	
:ENABle <NRf>	Program the enable register.	
:ENABle?	Query the enable register.	

Table 5-11 (continued)
STATus command summary

Command	Description	Reference
:STATus		
:QUEStionable		
:PTRansition <NRf>	Program the positive transition register.	
:PTRansition?	Query the positive transition register.	
:NTRansition <NRf>	Program the negative transition register.	
:NTRansition?	Query the negative transition register.	
:CONDition?	Query the condition register.	
:PRESet	Return status registers to default states.	5.16.6
:QUEue	Path to access error queue:	5.16.7
[:NEXT]?	Query most recent error message.	
:ENABle <list>	Specify error and status messages for queue.	
:ENABle?	Query enabled messages.	
:DISable <list>	Specify messages not to be placed in queue.	
:DISable?	Query disabled messages.	

Notes:

1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.
5. The Model 7001 does not implement the :QUEStionable status commands. They are included in this table only because they are part of the SCPI structure.

5.16.1 [:EVENt]?

:STATus:OPERation[:EVENt]?	Query Operation Event Register
:STATus:OPERation:TRIGger[:EVENt]?	Query Trigger Event Register
:STATus:OPERation:ARM[:EVENt]?	Query Arm Event Register
:STATus:OPERation:ARM:SEQUENCE[:EVENt]?	Query Sequence Event Register

Short-form formats

:stat:oper?
:stat:oper:trig?
:stat:oper:arm?
:stat:oper:arm:seq?

Defaults

Power-up	Clears (0) all bits
*CLS	Clears (0) all bits
:STATus:PRESet	No effect

Description

These query commands are used to query the event registers. After sending one of these commands and addressing the Model 7001 to talk, a decimal value is sent to the computer. The binary equivalent of this value determines which bits in the appropriate register are set. The event registers are shown in Figure 5-17 through Figure 5-20. Note that querying an event register clears the bits in that register.

For example, assume that querying the Operation Event Register results in an acquired decimal value of 34. The binary equivalent is 0000 0000 0010 0010. For this binary value, bits B5 and B1 of the Operation Event Register are set.

The significance of a set bit in these registers depend on how the transition filter is programmed (see :PTRansition and :NTRansition commands). If an event is programmed for a positive transition (PTR), the corresponding bit in this register will set when the event occurs (0 to 1 transition). If the event is instead programmed for a negative transition (NTR), the bit will set when the event becomes not true (1 to 0 transition).

Operation event register:

Bit B0 — Not used.

Bit B1, Settling (Set) — Set bit indicates that the scan is currently in the settling period for a relay (PTR) or the settling period has expired (NTR).

Bits B2, B3 and B4 — Not used.

Bit B5, Waiting for Trigger (Trig) — Set bit indicates that the instrument is waiting in the Trigger Layer of the trigger model (PTR) or that it has left the Trigger Layer (NTR).

Bit B6, Waiting for Arm (Arm) — Set bit indicates that the instrument is waiting in an Arm Layer of the trigger model (PTR) or operation has passed from the arm layers into the trigger layer (NTR).

Bits B7, B8 and B9 — Not used.

Bit B10, Idle — Set bit indicates that the instrument is in the idle state (PTR) or has left the idle state to perform a scan (NTR).

Bits B11 through B15 — Not used.

Bit Position	(B15 - B11)	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	Idle	—	—	—	Arm	Trig	—	—	—	Set	—
Decimal Weighting	—	1024 (2^{10})	—	—	—	64 (2^6)	32 (2^5)	—	—	—	2 (2^1)	—
Value	—	0/1	—	—	—	0/1	0/1	—	—	—	0/1	—

Value : 1 = Operation Event Set
0 = Operation Event Cleared

Events : Idle = Idle state of the 7001
Arm = Waiting for Arm
Trig = Waiting for Trigger
Set = Settling

Figure 5-17
Operation Event Register

Trigger Event Register:

Bit B0 — Not used.

Bit B1, Sequence 1 (Seq1) — Set bit indicates that the instrument is in the Trigger Layer (PTR), or that the instrument has exited from the Trigger Layer (NTR).

Bits B2 through B15 — Not used.

Bit Position	B15 - B2	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2^1)	—
Value	—	0/1	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Events : Seq 1 = Sequence 1

Figure 5-18
Trigger Event Register

Arm Event Register:

Bit B0 — Not used.

Bit B1, Sequence 1 (Seq1) — Set bit indicates that the instrument is in an arm layer (PTR), or that the instrument has exited from the arm layers (NTR).

Bits B2 through B15 — Not used.

Bit Position	B15 - B2	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2^1)	—
Value	—	0/1	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Event : Seq 1 = Sequence 1

Figure 5-19
Arm Event Register

Sequence Event Register:

Bit B0 — Not used.

Bit B1, Layer 1 (Lay1) — Set bit indicates that instrument operation is in Arm Layer 1 (PTR), or that operation has exited from Arm Layer 1 (NTR).

Bit B2, Layer 2 (Lay2) — Set bit indicates that instrument operation is in Arm Layer 2 (PTR), or that operation has exited from Arm Layer 2 (NTR).

Bits B3 through B15 — Not used.

Bit Position	B15 - B3	B2	B1	B0
Event	—	Lay2	Lay1	—
Decimal Weighting	—	4 (2^2)	2 (2^1)	—
Value	—	0/1	0/1	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Event : Lay1 = Layer 1
Lay2 = Layer 2

Figure 5-20
Sequence Event Register

Programming example

```
10   OUTPUT 707; ":stat:oper?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10	Queries the register.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the decimal value that defines which bits in the register are set.

5.16.1 :ENABle <NRf>

:STATus:OPERation:ENABle <NRf>	Program Operation Event Enable Register
:STATus:OPERation:TRIGger:ENABle <NRf>	Program Trigger Event Enable Register
:STATus:OPERation:ARM:ENABle <NRf>	Program Arm Event Enable Register
:STATus:OPERation:ARM:SEQUENCE:ENABle <NRf>	Program Sequence Event Enable Register

Parameters

<NRf>	= 0	Clear enable register
	= 2	Set bit B1 of enable register
	= 4	Set bit B2 of enable register
	= 32	Set bit B5 of enable register
	= 64	Set bit B6 of enable register
	= 1024	Set bit B10 of enable register

Short-form formats

:stat:oper:enab <NRf>
:stat:oper:trig:enab <NRf>
:stat:oper:arm:enab <NRf>
:stat:oper:arm:seq:enab <NRf>

Defaults

Power-up	Clears (0) all bits
*CLS	No effect
:STATus:PRESet	Clears (0) all bits

Query commands

:ENABle?	Query enable register
Short-form formats:	:stat:oper:enab? :stat:oper:trig:enab? :stat:oper:arm:enab? :stat:oper:arm:seq:enab?
Response message:	Decimal value (see Note)

Note: The binary equivalent of this decimal value indicates which bits in the register are set. For example, for an acquired decimal value of 96, the binary equivalent is 0000 0000 0110 0000. For this binary value, bits B5 and B6 are set.

Description

These commands are used to set the contents of the event enable registers (see Figure 5-21 through Figure 5-24). An :ENABle command is sent with the decimal equivalent of the binary value that determines the desired state (0 or 1) of each bit in the appropriate register.

Each event enable register is used as a mask for events (see [:EVENt] for descriptions of events). When a bit in an event enable register is cleared (0), the corresponding bit in the event register is masked and thus, cannot set the corresponding summary bit of the next register set in the status structure. Conversely, when a bit in an event enable register is set (1), the corresponding bit in the event register is unmasked. When the unmasked bit in the event register sets, the summary bit of the next register set in the status structure will set.

The decimal weighting of the bits for each event enable register are included in Figure 5-21 through Figure 5-24. The sum of the decimal weights of the bits that you wish to set is sent as the parameter (<NRf>) for the appropriate :ENABle command. For example, to set the Idle and Set bits of the Operation Event Enable Register, send the following command:

```
:stat:oper:enab   1026
```

```
where;   Idle (bit B10)   =   1024
         Set (bit B1)     =      2
                              ----
         <NRf>            =   1026
```

Programming example

```
10   OUTPUT 707; ":stat:oper:enab   96; enab?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10	Sets Bits B5 and B6 of the Operation Event Enable Register, and then queries the register.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the decimal value that defines which bits in the register are set (96).

Bit Position	(B15 - B11)	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	—	Idle	—	—	—	Arm	Trig	—	—	—	Set	—
Decimal Weighting	—	1024 (2^{10})	—	—	—	64 (2^6)	32 (2^5)	—	—	—	2 (2^1)	—
Value	—	0/1	—	—	—	0/1	0/1	—	—	—	0/1	—

Value : 1 = Enable Operation Event
0 = Disable (Mask) Operation Event

Events : Idle = Idle state of the 7001
Arm = Waiting for Arm
Trig = Waiting for Trigger
Set = Settling

Figure 5-21
Operation Event Enable Register

Bit Position	(B15 - B2)	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2^1)	—
Value	—	0/1	—

Value : 1 = Enable Trigger Event
0 = Disable (Mask) Trigger Event

Events : Seq 1 = Sequence 1

Figure 5-22
Trigger Event Enable Register

Bit Position	(B15 - B2)	B1	B0
Event	——	Seq1	—
Decimal Weighting	——	2 (2^1)	—
Value	——	0/1	—

Value : 1 = Enable Arm Event
0 = Disable (Mask) Arm Event

Event : Seq 1 = Sequence 1

Figure 5-23
Arm Event Enable Register

Bit Position	(B15 - B3)	B2	B1	B0
Event	——	Lay2	Lay1	—
Decimal Weighting	——	4 (2^2)	2 (2^1)	—
Value	——	0/1	0/1	—

Value : 1 = Event Bit Set
0 = Event Bit Cleared

Event : Lay1 = Layer 1
Lay2 = Layer 2

Figure 5-24
Sequence Event Enable Register

5.16.2 :PTRansition <NRf>

:STATus:OPERation:PTRansition <NRf>	Program Operation Transition Filter (PTR).
:STATus:OPERation:TRIGger:PTRansition <NRf>	Program Trigger Transition Filter (PTR).
:STATus:OPERation:ARM:PTRansition <NRf>	Program Arm Transition Filter (PTR).
:STATus:OPERation:ARM:SEQuence:PTRansition <NRf>	Program Sequence Transition Filter (PTR).

Parameters

<NRf>	= 0	Clear PTR register
	= 2	Set bit B1 of PTR register
	= 4	Set bit B2 of PTR register
	= 32	Set bit B5 of PTR register
	= 64	Set bit B6 of PTR register
	= 1024	Set bit B10 of PTR register

Short-form formats

```
:stat:oper:ptr   <NRf>
:stat:oper:trig:ptr   <NRf>
:stat:oper:arm:ptr   <NRf>
:stat:oper:arm:seq:ptr   <NRf>
```

Defaults

Power-up	Sets (1) all bits
*CLS	No effect
:STATus:PRESet	Sets (1) all bits

Query commands

:PTRansition?	Query PTR register
Short-form formats:	:stat:oper:ptr? :stat:oper:trig:ptr? :stat:oper:arm:ptr? :stat:oper:arm:seq:ptr?
Response message:	Decimal value (see Note)

Note: The binary equivalent of this decimal value indicates which bits in the register are set. For example, for an acquired decimal value of 96, the binary equivalent is 0000 0010 0110 0000. For this binary value, bits B6 and B5 are set.

Description

These commands are used to program the positive transition (PTR) registers. A positive transition is defined as a 0 to 1 state change in the condition register. Thus, when a an event is programmed for a positive transition, the appropriate bit in the corresponding event register will set when the corresponding bit in the condition register changes from 0 to 1. For example, if bit B1 of the Positive Transition Register of of the Operation Transition Filter is set, then the relay settling event is programmed for a positive transition. The Set bit (B1) in the Operation Event Register will set at the start of the relay settling period. For details on register structure, see paragraph 5.6.

The PTR registers are shown in Figure 5-25A through Figure 5-32A and include the decimal weight of each bit. The sum of the decimal weights of the bits that you wish to set is the parameter

(<NRf>) that is sent with the command. For example, to program the Arm (B6) and Trig (B5) operation events for positive transitions, send the following command:

```
:stat:oper:ptr  96
```

where; Arm (bit B6) = 64
Trig (bit B5) = 32
<NRf> = 96

Effects of positive transitions on the Operation Event Register:

Operation Event	Positive Transition Effect On Operation Event Register
Settling	Sets B1 at the start of the settling period.
Trigger Layer	Sets B5 when waiting in the Trigger Layer.
Arm Layer	Sets B6 when waiting in an Arm Layer.
Idle	Sets B10 when entering the idle state.

Bit Position	(B15 - B11)	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	——	Idle	—	—	—	Arm	Trig	—	—	—	Set	—
Decimal Weighting	——	1024 (2^{10})	—	—	—	64 (2^6)	32 (2^5)	—	—	—	2 (2^1)	—
Value	——	0/1	—	—	—	0/1	0/1	—	—	—	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	(B15 - B11)	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Event	——	Idle	—	—	—	Arm	Trig	—	—	—	Set	—
Decimal Weighting	——	1024 (2^{10})	—	—	—	64 (2^6)	32 (2^5)	—	—	—	2 (2^1)	—
Value	——	0/1	—	—	—	0/1	0/1	—	—	—	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 5-25
Operation Transition Filter

Effects of positive transitions on the Trigger Event Register:

Trigger Event	**Positive Transition Effect On Trigger Event Register**
Sequence 1	Sets B1 when waiting in Trigger Layer.

Bit Position	(B15 - B2)	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2^1)	—
Value	—	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	(B15 - B2)	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2^1)	—
Value	—	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 5-26
Trigger Transition Filter

Effects of positive transitions on the Arm Event Register:

Arm Event	Positive Transition Effect On Arm Event Register
Sequence 1	Sets B1 when in an Arm Layer.

Bit Position	(B15 - B2)	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2^1)	—
Value	—	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	(B15 - B2)	B1	B0
Event	—	Seq1	—
Decimal Weighting	—	2 (2^1)	—
Value	—	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 5-27
Arm Transition Filter

Effects of positive transitions on the Sequence Event Register:

Sequence Event	Positive Transition Effect On Sequence Event Register
Layer 1	Sets B1 when in Arm Layer 1.
Layer 2	Sets B2 when in Arm Layer 2.

Bit Position	(B15 - B3)	B2	B1	B0
Event	—	Lay2	Lay1	—
Decimal Weighting	—	4 (2^2)	2 (2^1)	—
Value	—	0/1	0/1	—

Value : 1 = Enable Positive Transition
0 = Disable Positive Transition

A) Positive Transition (PTR) Register

Bit Position	(B15 - B3)	B2	B1	B0
Event	—	Lay2	Lay1	—
Decimal Weighting	—	4 (2^2)	2 (2^1)	—
Value	—	0/1	0/1	—

Value : 1 = Enable Negative Transition
0 = Disable Negative Transition

B) Negative Transition (NTR) Register

Figure 5-28
Sequence Transition Filter

Programming example

```
10  OUTPUT 707; ":stat:oper:ptr   1026; ptr?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10	Sets Bits B1 and B10 of the PTR Operation Transition Filter, and then queries the register.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the decimal value that defines which bits in the register are set (1026).

5.16.3 :NTRansition <NRf>

:STATus:OPERation:NTRansition <NRf>	Program Operation Transition Filter (NTR).
:STATus:OPERation:TRIGger:NTRansition <NRf>	Program Trigger Transition Filter (NTR).
:STATus:OPERation:ARM:NTRansition <NRf>	Program Arm Transition Filter (NTR).
:STATus:OPERation:ARM:SEQuence:NTRansition <NRf>	Program Sequence Transition Filter (NTR).

Parameters

<NRf> = 0	Clear NTR register
= 2	Set bit B1 of NTR register
= 4	Set bit B2 of NTR register
= 32	Set bit B5 of NTR register
= 64	Set bit B6 of NTR register
= 1024	Set bit B10 of NTR register

Short-form formats

:stat:oper:ntr <NRf>
:stat:oper:trig:ntr <NRf>
:stat:oper:arm:ntr <NRf>
:stat:oper:arm:seq:ntr <NRf>

Defaults

Power-up	Clears (0) all bits
*CLS	No effect
:STATus:PRESet	Clears (0) all bits

Query commands

:NTRansition?	Query NTR register
Short-form formats:	:stat:oper:ntr? :stat:oper:trig:ntr? :stat:oper:arm:ntr? :stat:oper:arm:seq:ntr?
Response message:	Decimal value (see Note)

Note: The binary equivalent of this decimal value indicates which bits in the register are set. For example, for an acquired decimal value of 96, the binary equivalent is 0000 0000 0110 0000. For this binary value, bits B6 and B5 are set.

Description

These commands are used to program the negative transition (NTR) registers. A negative transition is defined as a 1 to 0 state change in the condition register. Thus, when an event is programmed for a negative transition, the appropriate bit in the corresponding event register will set when the corresponding bit in the condition register changes from 1 to 0. For example, if bit B1 of the Negative Transition Register of of the Operation Transition Filter is set, then the operation event is programmed for a negative transition. The Set bit (B1) in the Operation Event Register will set at the end of the relay settling period. For details on register structure, see paragraph 5.6.

The NTR registers are shown in Figure 5-25B through Figure 5-32B and include the decimal weight of each bit. The sum of the decimal weights of the bits that you wish to set is the parameter (<NRf>) that is sent with the command. For example, to program the Arm (B6) and Trig (B5) events for negative transitions, send the following command:

```
:stat:oper:ntr   96
```

where; Arm (bit B6) = 64
Trig (bit B5) = 32
<NRf> = 96

Effects of negative transitions on the Operation Event Register:

Operation Event	Negative Transition Effect On Operation Event Register
Settling	Sets B1 at the end of the settling period.
Trigger Layer	Sets B5 when leaving the Trigger Layer.
Arm Layer	Sets B6 when leaving an Arm Layer.
Idle	Sets B10 when leaving the idle state.

Effects of negative transitions on the Trigger Event Register:

Trigger Event	Negative Transition Effect On Trigger Event Register
Sequence 1	Sets B1 when leaving the Trigger Layer.

Effects of negative transitions on the Arm Event Register:

Arm Event	Negative Transition Effect On Arm Event Register
Sequence 1	Sets B1 when leaving an Arm Layer.

Effects of negative transitions on the Sequence Event Register:

Sequence Event	Negative Transition Effect On Sequence Event Register
Layer 1	Sets B1 when leaving Arm Layer 1.
Layer 2	Sets B2 when leaving Arm Layer 2.

Programming example

```
10  OUTPUT 707; “:stat:oper:ntr   1026; ntr?”
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10	Sets Bits B1 and B10 of the NTR Operation Transition Filter, and then queries the register.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the decimal value that defines which bits in the register are set (1026).

5.16.4 :CONDition?

:STATus:OPERation:CONDition?	Query Operation Condition Register
:STATus:OPERation:TRIGger:CONDition?	Query Trigger Condition Register
:STATus:OPERation:ARM:CONDition?	Query Arm Condition Register
:STATus:OPERation:ARM:SEQuence:CONDition?	Query Sequence Condition Register

Short-form formats

:stat:oper:cond?
:stat:oper:trig:cond?
:stat:oper:arm:cond?
:stat:oper:arm:seq:cond?

Description

These query commands are used to query the contents of the condition registers. Each set of event registers (except the Standard Event register set) has a condition register. A condition register is similar to its corresponding event register, except that it is a real-time register that constantly updates to reflect the current operating status of the instrument.

See [:EVENt] for register bit descriptions. Note from the status structure (paragraph 5.6) that the condition registers precede the transition filters. Thus, only the PTR descriptions apply to the condition registers.

After sending one of these commands and addressing the Model 7001 to talk, a decimal value is sent to the computer. The binary equivalent of this decimal value indicates which bits in the register are set.

For example, if sending :stat:oper:cond? returns a decimal value of 1024 (binary 0000 0100 0000 0000), bit B10 of the Operation Condition Register is set indicating that the instrument is in the idle state.

Programming example

```
10  OUTPUT 707; ":stat:oper:cond?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Queries the Operation Condition Register.
Line 20 Addresses the 7001 to talk.
Line 30 Displays the decimal value that defines which bits in the register are set.

5.16.5 :PREset

:STATus:PREset Return 7001 to default conditions

Short-form format

:stat:pres

Description

When this command is sent, the SCPI event registers are affected as follows:

1. All bits of the positive transition filter registers are set to one (1).
2. All bits of the negative transition filter registers are cleared to zero (0).
3. All bits of the following registers are cleared to zero (0):
   A. Operation Event Enable Register.
   B. Questionable Event Enable Register.
4. All bits of the following registers are set to one (1):
   A. Trigger Event Enable Register.
   B. Arm Event Enable Register.
   C. Sequence Event Enable Register.

Note: Registers not included in the above list are not affected by this command.

Programming example

The following programming example demonstrates how to use the :PRESet command of the STATus subsystem:

```
OUTPUT 707; ":stat:pres"
```

5.16.6 :QUEue commands

[:NEXT]?

:STATus:QUEue[:NEXT]?	Query Error Queue

Short-form format :stat:que?

Defaults

Power-Up	Clears Error Queue
*CLS	Clears Error Queue
:STATus:PRESet	No effect

Description As error and status messages occur, they are placed into the Error Queue. This query command is used to read those messages.

The Error Queue is a first-in, first-out (FIFO) register. Every time you query the queue, the "oldest" message is read and that message is then removed from the queue. The queue will hold up to 10 messages. If the queue becomes full, the message "350, 'Queue Overflow'" will occupy the last memory location in the register. On power-up, the Error Queue is empty. When the Error Queue is empty, the message "0, 'No error'" is placed in the Error Queue.

The messages in the queue are preceded by a number. Negative (-) numbers are used for SCPI defined messages, and positive (+) numbers are used for Keithley defined messages. The messages are listed in Table 4-1.

After this command is sent and the Model 7001 is addressed to talk, the "oldest" message in the queue is sent to the computer.

Note: The :STATus:QUEue[:NEXT]? query command performs the same function as the :SYSTem:ERRor? query command (see System Subsystem).

Programming example The following program will read the "oldest" message in the Error Queue:

```
5    DIM A$ [30]
10   OUTPUT 707; ":stat:que?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 5	Increase string size to accommodate the length of the messages.
Line 10	Requests the "oldest" message in the queue.
Line 20	Addresses the Model 7001 to talk.
Line 30	Displays the message on the CRT.

:ENABle <list>

:STATus:QUEue:ENABle <list> Enable messages for Error Queue

Parameters

list = (numlist)

where; numlist is a specified list of messages that you wish to enable for the Error Queue.

Short-form format

:stat:que:enab (numlist)

Defaults

Power-up	Enable error events, disable status events
*CLS	No effect
:STATus:PRESet	Enable error events, disable status events

Query commands

:ENABle?	Query list of enabled messages
Short-form format:	:stat:que:enab?
Response message:	numlist

Description

On power-up, all error messages are enabled and will go into the Error Queue as they occur. Status messages are not enabled and will not go into the queue. This command is used to specify which messages you want enabled. Messages not specified will be disabled and prevented from entering the queue.

When this command is sent, all messages will first be disabled, then the messages specified in the list will be enabled. Thus, the returned list (:ENABle?) will contain all the enabled messages.

Messages are specified by numbers (see Table 4-1). The following examples show various forms for expressing a message numlist:

Numlist = -110	Single message.
= -110, -140, -222	Messages separated by commas.
= -110:-222	Range of messages (-100 through -222).
= -110:-222, -230	Range entry and single entry separated by a comma.

Note: To disable all messages from entering the Error Queue, send the following command:

:stat:que:enab ()

To enable all Model 7001 messages, send the following command: :stat:que:enab (-150: +550)

Programming example

```
10  OUTPUT 707; “:stat:que:enab   (0:-999); enab?”
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10	Enables all SCPI defined messages.
Line 20	Addresses the Model 7001 to talk.
Line 30	Displays the enable messages (0:-999).

:DISable <list>

:STATus:QUEue:DISable <list>	Disable messages for Error Queue

Parameters

<list> = (numlist)

where; numlist is a specified list of messages that you wish to disable for the Error Queue.

Short-form format

:stat:que:dis (numlist)

Defaults

Power-up	Disable status events, enable error events
*CLS	No effect
:STATus:PRESet	Disable status events, enable error events

Query commands

:DISable?	Query list of disabled messages
Short-form format:	:stat:que:dis?
Response message:	numlist

Description

On power-up, all error messages are enabled and will go into the Error Queue as they occur. Status messages are not enabled and will not go into the queue. This command is used to specify which messages you want disabled. Disabled messages are prevented from going into the Error Queue.

Messages are specified by numbers (see Table 4-1). The following examples show various forms for expressing a message numlist:

Numlist = -110	Single message.
= -110, -140, -222	Messages separated by commas.
= -110:-222	Range of messages (-100 through -222).
= -110:-222, -230	Range entry and single entry separated by a comma.

Programming example

```
10  OUTPUT 707; ":stat:que:dis  (-140:-150); dis?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10	Disables messages -140 through -150.
Line 20	Addresses the Model 7001 to talk.
Line 30	Displays the disabled messages (-140:-150).

5.17 :SYSTem Subsystem

The system subsystem contains miscellaneous commands and are summarized in Table 5-12.

Table 5-12
SYSTem command summary

Command	Description	Reference
:SYSTem		
:PRESet	Return to :SYST:PRES defaults.	5.17.1
:POSetup <name>	Select power-on setup: RST, PRESet, SAV0-SAV9.	5.17.2
:POSetup?	Query power-on setup.	
:VERSion?	Query revision level of SCPI standard.	5.17.3
:ERRor?	Query Error Queue.	5.17.4

Notes:

1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one sapce is required between a command word and the parameter.

5.17.1 :PRESet

:SYSTem:PRESet Return to :SYSTem:PRESet defaults

Short-form format :syst:pres

Description This command returns the instrument to states optimized for front panel operation. Table 5-5 defines the default conditions for this command.

Programming example

```
OUTPUT 707; ":syst:pres"        ! Return 7001 to default states
```

5.17.2 :POSetup <name>

:SYSTem:POSetup <name> Program power-on defaults

Parameters

<name> = RST Select *RST defaults on power up
= PRESet Select :SYSTem:PRESet defaults on power up
= SAVX Select saved defaults on power up

where; X = 0 to 9

Short-form format :syst:pos <name>

Query commands

:POSetup?	Query power-on setup
Short-form format:	:syst:pos?
Response message:	RST, PRES or SAV0-SAV9

Description

This command is used to program the power-on defaults. With RST selected, the instrument will power up to the *RST default conditions. With PRES selected, the instrument will power up to the :SYStem:PRESet default conditions. Table 5-5 defines the default conditions for these commands.

With one of the SAV parameters selected, the instrument will power on to the setup that is saved in the specified memory location using the *SAV command.

Programming example

```
10   OUTPUT 707; ":syst:pos   pres; pos?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10	Two commands in this program message; the first selects :SYSTem:PRESet power-on defaults, and the second queries the power-on setup.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the power-on setup (PRES).

5.17.3 :VERSion?

:SYSTem:VERSion? Read SCPI version

Short-form format

:syst:vers?

Description

This query command is used to read the version of the SCPI standard being used by the Model 7001. After sending this command and addressing the Model 7001 to talk, the version code will be sent to the computer. Example code:

```
1991.0
```

The above response message indicates the version of the SCPI standard.

Programming example

```
10   OUTPUT 707; ":syst:vers?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10	Reads the version of the SCPI standard.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the SCPI standard version.

5.17.4 :ERRor?

:SYSTem:ERRor? Read Error Queue

Short-form format

:syst:err?

Defaults

Power-up	Clears Error Queue
*RST	No effect
*CLS	Clears Error Queue
DCL, SDC	No effect
:SYSTem:PRESet	No effect
:STATus:PRESet	No effect

Description

As error and status messages occur, they are placed into the Error Queue. This query command is used to read those messages. The Error Queue is a first-in, first-out (FIFO) register. Every time you read the queue, the “oldest” message is read and that message is then removed from the queue.

If the queue becomes full, the message “350, ‘Queue Overflow’” will occupy the last memory location in the register. On power-up, the queue is empty. When the Error Queue is empty, the message “0, ‘No error’” is placed in the Error Queue.

The messages in the queue are preceded by a number. Negative (-) numbers are used for SCPI defined messages, and positive (+) numbers are used for Keithley defined messages. Table 4-1 lists the messages.

After this command is sent and the Model 7001 is addressed to talk, the “oldest” message in the queue is sent to the computer.

Note: The :SYSTem:ERRor? query command performs the same function as the :STATus:QUEue? query command (see STATus subsystem).

Programming example

```
10  DIM A$ [30]
20  OUTPUT 707; “:syst:err?”
30  ENTER 707; A$
40  PRINT A$
50  END
```

Line 10	Increases string size to accommodate message.
Line 20	Reads the Error Queue.
Line 30	Addresses the 7001 to talk.
Line 40	Displays the message from the Error Queue.

5.18 Trigger subsystem

The Trigger Subsystem is made up of a series of commands and subsystems to configure the three layers of the Trigger Model (see Figure 5-13). These commands and subsystems are summarized in Table 5-13.

Table 5-13
Trigger command summary

Command	Description	Reference
:INITiate	Subsystem command path:	5.18.1
[:IMMediate]	Initiate one trigger cycle.	
:CONTinuous <b>	Enable (1 or ON) or disable (0 or OFF) continuous initiation of trigger system.	
:CONTinuous?	Query continuous initiation.	
:ABORt	Reset trigger system.	5.18.2
:ARM[:SEQuence[1]]	Subsystem command path to configure arm layers:	
[:LAYer[1]]	Path to program arm layer 1:	
:IMMediate	Immediatey go to Layer2.	5.18.3
:COUNt <n>	Program arm count (1 to 9999, or INF).	5.18.4
:COUNt?	Query arm count.	
:SOURce <name>	Select control source: HOLD, IMMediate, MANual, BUS, TLINk, EXTernal.	5.18.6
:SOURce?	Query control source.	
:SIGNal	Loop around control source.	5.18.8
:TCONfigure	Path to configure Triggers:	5.18.9
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass:	
:DIRection?	Query direction.	
:ASYNchronous	Path to configure asynchronous Trigger Link:	
:ILINe <NRf>	Select input line (1 to 6).	
:ILINe?	Query input line.	
:OLINe <NRf>	Select output line (1 to 6).	
:OLINe?	Query output line.	
:LAYer2	Path to program arm layer 2:	
:IMMediate	Immediately go to Trigger Layer.	5.18.3
:COUNt <n>	Program scan count (1 to 9999 or INF).	5.18.4
:COUNt?	Query scan count.	
:DELay <n>	Program delay (0 to 99999.999 sec)	5.18.5
:DELay?	Query delay.	
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.	5.18.6
:SOURce?	Query control source.	
:TIMer <n>	Set timer interval (0 to 99999.999 sec).	5.18.7
:TIMer?	Query timer.	
:SIGNal	Loop around control source.	5.18.8

Table 5-13 (continued)
Trigger command summary

Command	Description	Reference
:ARM[:SEQuence[1]]		
:LAYer2		
:TCONfigure	Path to configure Triggers:	5.18.9
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass.	
:DIRection?	Query direction.	
:ASYNchronous	Path to configure asynchronous Trigger Link:	
:ILINe <NRf>	Select input line (1 to 6).	
:ILINe?	Query input line.	
:OLINe <NRf>	Select output line (1 to 6).	
:OLINe?	Query output line.	
:TRIGger[:SEQuence[1]]	Path to program trigger layer:	
:IMMediate	Immediately perform a scan step.	5.18.3
:COUNt <n>	Program measure count (1 to 9999, or INF).	5.18.4
:AUTO <b>	Enable (1 or ON) or disable (0 or OFF) auto-count (scan-list-length).	
:AUTO?	Query auto-count.	
:COUNt?	Query measure count.	
:DELay <n>	Program delay (0 to 99999.999 sec)	5.18.5
:DELay?	Query delay.	
:SOURce <name>	Select control source: HOLD, IMMediate, TIMer, MANual, BUS, TLINk, EXTernal.	5.18.6
:SOURce?	Query control source.	
:TIMer <n>	Set timer interval (0 to 99999.999 sec).	5.18.7
:TIMer?	Request the programmed timer interval.	
:SIGNal	Loop around control source.	5.18.8
:TCONfigure	Path to configure Triggers:	5.18.9
:PROTocol <name>	Select protocol: ASYNchronous, SSYNchronous.	
:PROTocol?	Query protocol.	
:DIRection <name>	Enable (SOURce) or disable (ACCeptor) Bypass.	
:DIRection?	Query direction.	
:ASYNchronous	Path to configure asynchronous Trigger Link:	
:ILINe <NRf>	Select input line (1 to 6).	
:ILINe?	Query input line.	
:OLINe <NRf>	Select output line (1 to 6).	
:OLINe?	Query output line.	
:SSYNchronous	Path to configure semi-synchronous Trigger Link:	
:LINE <NRf>	Select trigger line (1 to 6).	
:LINE?	Query trigger line.	

Notes:

1. Brackets ([ ]) are used to denote optional character sets. These optional characters do not have to be included in the program message. Do not use brackets ([ ]) in the program message.
2. Angle brackets (< >) are used to indicate parameter type. Do not use angle brackets (< >) in the program message.
3. Upper case characters indicate the short-form version for each command word.
4. At least one space is required between a command word and the parameter.

NOTE

Front panel operation and IEEE-488 operation use different nomencalture for the three layers of the Trigger Model and is summarized as follows:

Trigger Model Layer Nomenclature

Layer	**Layer Name; Front Panel Operation**	**Layer Name; IEEE-488 Bus Operation**
First layer	Arm Layer	Arm Layer 1
Second layer	Scan Layer	Arm Layer 2
Third layer	Channel Layer	Trigger Layer

5.18.1 :INITiate commands

[:IMMediate]

:INITiate[:IMMediate] Take 7001 out of idle

Short-form format :init

Description This command takes the Model 7001 out of the idle state. After the completion of a scan, the instrument will return to the idle state (if continuous initiation is disabled; see next command). This is an overlapped command (see *OPC, *OPC?, *TRG and *WAI).`

Programming example

```
OUTPUT 707; “:init”                ! Takes 7001 out of the idle state.
```

:CONTinuous <b>

:INITiate:CONTinuous <b> Control continuous initiation

Parameters

<b> = 0 or OFF Disable continuous initiation
= 1 or ON Enable continuous initiation

Short-form format :init:cont <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	ON

Query commands	:CONTinuous?	Query continuous initiation
	Short-form format:	:init:cont?
	Response message:	1 (on) or 0 (off)

Description

When continuous initiation is selected (ON), the instrument is taken out of the idle state. At the conclusion of all programmed operations, the instrument will return to Arm Layer 1. This is an overlapped command (see *OPC, *OPC?, *TRG and *WAI).

NOTE

In the event of a "Too many channels closed" error, all channels will open, the instrument will go into idle, and continuous initiation will disable (:INITiate:CONTinuous OFF).

Programming example

```
OUTPUT 707; ":init:cont   on"         ! Select continuous initiation
```

5.18.2 :ABORt

:ABORt Abort operation

Short-form format

:abor

Description

When this action command is sent, the Model 7001 will abort its current operations and return to the top of the Trigger Model (idle state). If the *OPC command has been sent, the OPC bit in the Standard Event Status Register will set. If continuous initiation is disabled, the instrument will go into the idle state. If continuous initiation is enabled, operation will continue on into Arm Layer 1.

The abort command will reset the Source Bypasses of the Trigger Model and reset the scan pointer back to the first channel in the scan list.

Programming example

```
OUTPUT 707; ":abor"                   ! Abort operation
```

5.18.3 :IMMediate

:ARM[:SEQuence[1]][:LAYer[1]]:IMMediate	Bypass arm control source
:ARM[:SEQuence[1]]:LAYer2:IMMediate	Bypass scan control source and delay
:TRIGger:[:SEQuence[1]]:IMMediate	Bypass channel control source and delay

Short-form formats

:arm:imm
:arm:lay2:imm
:trig:imm

Description

These action commands are used to bypass the specified layer of the Trigger Model. They are used when you do not wish to wait for the programmed event. Note from the Trigger Model (Figure 5-13) that :arm:lay2:imm and :trig:imm also bypass the Delay.

The instrument must be waiting for the appropriate event when the command is sent. Otherwise, an error will occur and the command will be ignored. When the command is sent, the bypass will occur and operation will continue on.

Note that :IMMediate is not an instrument setup command. As soon as this command is executed, it will attempt to bypass the specified trigger model layer.

Programming example

```
OUTPUT 707; ":arm:imm"          ! Bypass arm control source
```

5.18.4 :COUNt <n>

:ARM[:SEQuence[1]][:LAYer[1]]:COUNt <n>	Set Arm Layer 1 count
:ARM[:SEQuence[1]]:LAYer2:COUNt <n>	Set Arm Layer 2 count
:TRIGger[:SEQuence[1]]:COUNt <n>	Set Trigger Layer count

Parameters

<n>	= 1 to 99999	Specify count
	= INF	Sets count to infinite
	= DEFault	Sets count to 1
	= MINimum	Sets count to 1
	= MAXimum	Sets count to 9999

Short-form formats

:arm:coun <n>
:arm:lay2:coun <n>
:trig:coun <n>

Defaults

Power-up	Saved power-on setup
*RST	1 (all layers)
:SYSTem:PRESet	1 (Arm Layer 1) INF (Arm Layer 2) Scan-list-length (Trigger Layer)

Query commands

:COUNt?	Query programmed count
:COUNt? DEFault	Query *RST default count
:COUNt? MINimum	Query lowest allowable count
:COUNt? MAXimum	Query largest allowable count

Short-form formats:

:arm:coun?	:arm:lay2:coun?
:arm:coun? xxx	:arm:lay2:coun? xxx
:trig:coun?	
:trig:coun? xxx	

where; xxx = def, min or max

Response messages:	1 to 9999 (for finite count)
	+9.9e37 (for infinite count)

Description

These commands are used to specify how many times operation will loop around in the specified layer of operation. For example, if the channel count (:trig:coun) is set to 10, operation will continue to loop around in the Trigger Layer until 10 channels are scanned. After the 10th channel, operation will proceed back up to Arm Layer 2.

If you select a finite channel count (:trig:coun) that is greater than the scan-list-length, the first scan will end after the programmed number of channels are scanned. If programmed for another scan, the scan process will continue from the last scanned channel.

If you select an infinite channel count (:trig:coun), the scan will loop back to the beginning of the scan list after all channels in the list have been scanned. This process will continue indefinitely.

Note that this command is coupled to :TRIGger:COUNt:AUTO (auto-count). When auto-count is enabled, the channel count is set to the scan-list-length. When :TRIGger:COUNt is used to set the channel count, auto-count will automatically disable.

Programming example

```
10  OUTPUT 707; ":trig:coun   10; coun?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10	Sets the channel count to 10, and then queries the programmed arm count.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the programmed channel count (10).

:AUTO <b>

:TRIGger[:SEQuence[1]]:COUNt:AUTO <b> Control auto-count for Trigger Layer

Parameters

<b>	= 1 or ON	Enable auto-count (scan-list-length)
	= 0 or OFF	Disable auto-count

Short-form format

:trig:coun:auto <b>

Defaults

Power-up	Saved power-on setup
*RST	OFF
:SYSTem:PRESet	ON

Query commands

:AUTO?	Query auto-count
Short-form format:	:trig:coun:auto?
Response message:	1 (on) or 0 (off)

Description

With auto-count enabled, the channel count is automatically set to the scan-list-length. For example, if there are currently 36 channels in the scan list, then enabling auto-count will set the channel count to 36. While auto-count is enabled, changing the scan list count will change the trigger count.

If the scan list is empty, enabling auto-count will set the channel count to 1.

This command is coupled to :TRIGger:COUNt which is used to manually set the channel count. When :TRIGger:COUNt is used to set the channel count, auto-count will automatically disable.

Programming example

```
10   OUTPUT 707; ":scan   (@ 1!1:1!10)
20   OUTPUT 707; ":trig:coun:auto   on; auto?; :trig:coun?"
30   ENTER 707; A$
40   PRINT A$
50   END
```

Line 10	Defines a scan list (channels 1-10 of Slot 1).
Line 20	Enables auto-count, queries the state of auto-count and then queries the channel count.
Line 30	Addresses the 7001 to talk.
Line 40	Displays the state of auto-count and the channel count (1; 10).

5.18.5 :DELay <n>

:ARM[:SEQuence[1]]:LAYer2:DELay <n>	Set Arm Layer 2 delay
:TRIGger[:SEQuence[1]]:DELay <n>	Set Trigger Layer delay

Parameters

<n>	= 0 to 99999.999	Specify delay in seconds
	= DEFault	0 second delay
	= MINimum	0 second delay
	= MAXimum	99999.999 second delay

Short-form formats

:arm:lay2:del <n>
:trig:del <n>

Defaults

Power-up	Saved power-on setup
*RST	0 sec
:SYSTem:PRESet	0 sec

Query commands

:DELay?	Query the programmed delay
:DELay? DEFault	Query the *RST default delay
:DELay? MINimum	Query the lowest allowable delay
:DELay? MAXimum	Query the largest allowable delay
Short-form formats:	:arm:lay2:del? :trig:del? :arm:lay2:del? xxx :trig:del? xxx where; xxx = def, min or max
Response message:	0 to 99999.999 (seconds)

Description

These delay periods are used to delay operation in the specified layer (Arm Layer 2 and/or Trigger Layer). After the programmed event occurs, the instrument will wait until the delay period expires before proceeding on in the Trigger Model.

Note that Arm Layer 1 does not use a Delay.

Programming example

```
10  OUTPUT 707; ":trig:del   1; del?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10	Sets a one second delay for the Trigger Layer, and then queries the programmed delay.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the programmed delay (l).

5.18.6 :SOURce <name>

:ARM[:SEQuence[1]][:LAYer[1]]:SOURce <name>	Specify arm event control source
:ARM[:SEQuence[1]]:LAYer2:SOURce <name>	Specify scan event control source
:TRIGger[:SEQuence[1]]:SOURce <name>	Specify channel event control source

Parameters

<name> = HOLD	Hold operation in specified layer
= IMMediate	Pass operation through specified layer
= MANual	Select manual event
= BUS	Select GPIB trigger as event
= TLINk	Select Trigger Link as event
= EXTernal	Select External Triggering as event
= TIMer	Select timer as event Note: TIMer not available for Arm Layer 1

Short-form formats

:arm:sour <name>
:arm:lay2:sour <name>
:trig:sour <name>

Defaults

Power-up	Saved power-on setup
*RST	IMMediate (all layers)
:SYSTem:PRESet	IMMediate (Arm Layer 1 and Arm Layer 2), MANual (TRIGger Layer)

Query commands

:SOURce?	Query programmed control source.
Short-form formats:	:arm:sour? :arm:lay2:sour? :trig:sour?
Response message:	HOLD, MAN, IMM, BUS, TLIN, EXT or TIM

Description

These commands are used to select the event control source for the specified layer. With HOLD selected, operation will stop and wait indefinitely in the specified layer. While in HOLD, operation can be continued by sending the :IMMediate command or the :SIGNal command. Keep in mind however, that if the layer count >1, HOLD will again be enforced when operation loops back around.

With IMMediate selected (do not confuse :SOURce IMMediate with :IMMediate), operation will immediately pass through the specified layer.

A specific event can be used to control operation through a layer. With BUS selected, operation will continue when a GPIB trigger (GET or *TRG) is sent. With TLINk selected, operation will continue when an input trigger via the Trigger Link is received. With EXTernal selected, operation will continue when an External Trigger is received.

A TIMer event is available for Arm Layer 2 and the Trigger Layer. With TIMer selected for the specified layer, the event occurs at the beginning of the timer interval, and every time the timer times out. For example, if the Trigger Layer timer is programmed for a 30 second interval, the first pass through the Trigger Layer control source will occur immediately. Subsequent trigger events will then occur every 30 seconds. The interval for the timer is set using the :TIMer command. This timer interval is independent of the :DELay setting.

Programming example

```
10  OUTPUT 707; ":trig:sour   imm; sour?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10 Sets the channel control source to immediate, and then queries the programmed control source.

Line 20 Addresses the 7001 to talk.

Line 30 Displays the programmed channel control source (IMM).

5.18.7 :TIMer <n>

:ARM:SEQuence[1]]:LAYer2:TIMer <n>	Set interval for Arm Layer 2 timer
:TRIGger:SEQuence[1]]:TIMer <n>	Set interval for Trigger Layer timer

Parameters

<n>	= 0.001 to 99999.999	Specify timer interval in seconds
	= DEFault	0.1 second (Trigger Layer counter) 1 second (Arm Layer 2 counter)
	= MINimum	0.001 second
	= MAXimum	99999.999 seconds

Short-form formats

:arm:lay2:tim <n>
:trig:tim <n>

Defaults

Power-up	Saved power-on setup
*RST	0.001 second interval
:SYSTem:PRESet	0.001 second interval

Query commands

:TIMer?	Query programmed timer interval	
:TIMer? DEFault	Query *RST default timer interval	
:TIMer? MINimum	Query lowest allowable timer interval	
:TIMer? MAXimum	Query largest allowable timer interval	
Short-form format:	:arm:lay2:tim?	:trig:tim?
	:arm:lay2:tim? xxx	:trig:tim? xxx
	where; xxx = def, min or max	
Response message:	.001 to 99999.999	

Description

These commands are used to set the interval for the Arm Layer 2 and Trigger Layer timers. Note that the timer is in effect only if the timer is the selected control source. Also, note that Arm Layer 1 does not use a timer.

Programming example

```
10  OUTPUT 707; ":trig:tim   0.25; tim?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10	Sets the Trigger Layer timer for a 1/4 second interval, and then queries the programmed timer interval.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the timer interval (.25).

5.18.8 :SIGNal

:ARM[:SEQuence[1]][:LAYer[1]]:SIGNal	Bypass arm control source
:ARM[:SEQuence[1]]:LAYer2:SIGNal	Bypass scan control source
:TRIGger[:SEQuence[1]]:SIGNal	Bypass channel control source

Short-form format :arm:sign

Description These action commands are used to bypass the specified control source and are used when you do not wish to wait for the programmed event. Keep in mind that the instrument must be waiting for the appropriate event when the command is sent. Otherwise, an error will occur and this command will be ignored.

When this command is sent, the specified control source will be bypassed. This will allow operation to continue. Only the layer's source event between is bypassed; any :DELay time will be observed.

Note that :SIGNal is not an instrument setup command. As soon as this command is executed, it will attempt to bypass the control source.

Programming example

```
OUTPUT 707; ":trig:sign"          ! Bypass channel control source.
```

5.18.9 TCONfigure commands

:PROTocol <name>

:TRIGger[:SEQuence[1]]:TCONfigure:PROTocol <name>	Specify Trigger Link protocol

Parameters

<name> = ASYNchronous	Asynchronous Trigger Link mode
= SSYNchronous	Semi-synchronous Trigger Link mode

Short-form format :trig:tcon:prot <name>

Defaults

Power-up	Saved power-on setup
*RST	ASYNchronous
:SYSTem:PRESet	ASYNchronous

Query commands

:PROTocol?	Query programmed Trigger Link protocol
Short-form format:	:trig:tcon:prot?
Response message:	ASYN or SSYN

Description

This command is used to select the protocol for the Trigger Layer Trigger Link. With ASYNchronous selected, separate trigger lines are used for input and output triggers. With SSYNchronous selected, a single trigger line is used for both input and output triggers.

Note that Arm Layer 1 and Arm Layer 2 only use the asynchronous Trigger Link mode and therefore, the protocol does not have to be selected.

Programming example

```
10  OUTPUT 707; ":trig:tcon:prot   ssyn; prot?"
20  ENTER 707; A$
30  PRINT A$
40  END
```

Line 10	Selects semi-synchronous Trigger Link protocol, and then queries the selected protocol.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the Trigger Link protocol (SSYN).

:DIRection <name>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:DIRection <name>	Control arm Source Bypass
ARM[:SEQuence[1]]:LAYer2:TCONfigure:DIRection <name>	Control scan Source Bypass
:TRIGger[:SEQuence[1]]:TCONfigure:DIRection <name>	Control channel Source Bypass

Parameters

<name>	= SOURce	Enable Source Bypass
	= ACCeptor	Disable Source Bypass

Short-form formats

:arm:tcon:dir <name>
:arm:lay2:tcon:dir <name>
:trig:tcon:dir <name>

Defaults

Power-up	Saved power-on setup
*RST	ACCeptor (all layers)
:SYSTem:PRESet	ACCeptor (Arm Layer 1 and Arm Layer 2) SOURce (Trigger Layer)

Query commands

:DIRection?	Query Source Bypass state
Short-form formats:	:arm:tcon:dir? :arm:lay2:tcon:dir? :trig:tcon:dir?
Response message:	SOUR or ACC

Description

When a Source Bypass is enabled and the External or Trigger Link arm control source is selected, operation will loop around the appropriate control source on the initial pass through that layer. Note that the Source Bypass for Arm Layer 2 and the Trigger Layer also loops around the Delay.

If programmed for another pass through the specified layer (count >1), the bypass loop will not be in effect even though it will still be enabled. The bypass loop will be in effect if operation first goes back into the previous layer (or idle).

Enabling the Source Bypass for Arm Layer 1 and Arm Layer 2 also enables their Output Triggers. When operation leaves Arm Layer 1 or Arm Layer 2, the appropriate output trigger pulse will occur. If the Trigger Link (TLINk) control source is selected, the output trigger will be available on the programmed Trigger Link output line. For all other control source selections, the output trigger pulse will be available at the CHANNEL READY Output connector. The Output Trigger in these two layers is disabled when the Source Bypass is disabled.

The Output Trigger in the Trigger Layer is always enabled and occurs after the Device Action.

With ACCeptor selected, the bypass is disabled. Operation will not proceed through the specified layer until the appropriate event occurs.

Programming example

```
10   OUTPUT 707; “:trig:tcon:dir   sour; dir?”
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10	Enables the Source Bypass for the Trigger Layer and then queries the state of the Source Bypass.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the state of the Source Bypass (SOUR; enabled).

:ASYNchronous:ILINe <NRf>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:ASYNchronous:ILINe <NRf>	Select input trigger line; Arm Layer 1
:ARM[:SEQuence[1]]:LAYer2:TCONfigure:ASYNchronous:ILINe <NRf>	Select input trigger line; Arm Layer 2
:TRIGger[:SEQuence[1]]:TCONfigure:ASYNchronous:ILINe <NRf>	Select input trigger line; Trigger Layer

Parameters

<NRf>	= 1	Line #1
	= 2	Line #2
	= 3	Line #3
	= 4	Line #4
	= 5	Line #5
	= 6	Line #6

Short-form formats

:arm:tcon:asyn:ilin <NRf>
:arm:lay2:tcon:asyn:ilin <NRf>
:trig:tcon:asyn:ilin <NRf>

Defaults

Power-up	Saved power-on setup
*RST	1 (all layers)
:SYSTem:PRESet	1 (all layers)

Query commands

:ILINe?	Query programmed input line #
Short-form format:	:arm:tcon:asyn:ilin? :arm:lay2:tcon:asyn:ilin? :trig:tcon:asyn:ilin?
Response message:	1 to 6

Description

These commands are used to select an input line for the asynchronous Trigger Link of the specified layer. Keep in mind that asynchronous Trigger Link input and output (see :OLINe) cannot share the same line. If you assign the input to a line that is already being used for the output, an error will occur and the command will be ignored.

Programming example

```
10   OUTPUT 707; “:trig:tcon:asyn:ilin   3; ilin?”
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10	Assigns the asynchronous Trigger Link input of the Trigger Layer to line #3, and then queries the programmed input line.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the programmed input line # (3).

:ASYNchronous:OLINe <NRf>

:ARM[:SEQuence[1]][:LAYer[1]]:TCONfigure:ASYNchronous:OLINe <NRf>	Select output trigger line; Arm Layer 1
:ARM[:SEQuence[1]]:LAYer2:TCONfigure:ASYNchronous:OLINe <NRf>	Select output trigger line; Arm Layer 2
:TRIGger[:SEQuence[1]]:TCONfigure:ASYNchronous:OLINe <NRf>	Select output trigger line; Trigger Layer

Parameters

<NRf>	= 1	Line #1
	= 2	Line #2
	= 3	Line #3
	= 4	Line #4
	= 5	Line #5
	= 6	Line #6

Short-form formats

:arm:tcon:asyn:olin <NRf>
:arm:lay2:tcon:asyn:olin <NRf>
:trig:tcon:asyn:olin <NRf>

Defaults

Power-up	Saved power-on setup
*RST	2 (all layers)
:SYSTem:PRESet	2 (all layers)

Query commands

:OLINe?	Query programmed output line #
Short-form formats:	:arm:tcon:asyn:olin? :arm:lay2:tcon:asyn:olin? :trig:tcon:asyn:olin?
Response message:	1 to 6

Description

These commands are used to select an output line for the asynchronous Trigger Link of the specified layer. Keep in mind that asynchronous Trigger Link input and output cannot share the same line. If you assign the output to a line that is already being used for the input, an error will occur and the command will be ignored.

Programming example

```
10   OUTPUT 707; ":trig:tcon:asyn:olin   4; olin?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10	Assigns the asynchronous Trigger Link output of the Trigger Layer to line #4, and then queries the programmed output line.
Line 20	Addresses the 7001 to talk.
Line 30	Displays the programmed output line # (4).

:SSYNchronous:LINE <NRf>

:TRIGger[:SEQuence[1]]:TCONfigure:SSYNchronous Specify semi-synchronous Trigger Link line for the Trigger Layer

Parameters

<NRf> = 1 Line #1
= 2 Line #2
= 3 Line #3
= 4 Line #4
= 5 Line #5
= 6 Line #6

Short-form format

:trig:tcon:ssyn:line <NRf>

Defaults

Power-up	Saved power-on setup
*RST	1 (Trigger Layer)
:SYSTem:PRESet	1 (Trigger Layer)

Query commands

:LINE?	Query programmed output line #
Short-form format:	:trig:tcon:ssyn:line?
Response message:	1 to 6

Description

This command is used to select one of the six trigger lines for the semi-synchronous Trigger Link.

Programming example

```
10   OUTPUT 707; ":trig:tcon:ssyn:line   6; line?"
20   ENTER 707; A$
30   PRINT A$
40   END
```

Line 10	Selects line #6 for the Trigger Link, and then queries the programmed line #.
Line 20	Addresses the 7001 to talk.
Line 30	Displays selected line # (6).

6

Theory of Operation

6.1 Introduction

This section supplies a functional description of the Model 7001 in block diagram form, as well as details of the various circuit board assemblies and functional blocks within the instrument. Some of this information is presented in the form of simplified schematics. Detailed schematics and component layouts are located at the end of Section 8.

6.2 Overall functional description

The Model 7001 mainframe contains five major circuit boards, and accepts up to two plug-in relay cards which contain additional analog circuitry for signal paths and digital circuitry for control. Figure 6-1 is a block diagram showing interconnection of the Model 7001 digital board, front panel display board, micro-DIN board, BNC board, and system backplane. The board functions can be summarized as follows:

Digital board — a predominantly digital board which contains the main microprocessor, operating system, memory, IEEE-488 interface, and support circuitry.

Backplane board — provides the mechanical and electrical interface between the digital board and any cards plugged into the Model 7001 card slots.

Display board — includes the vacuum fluorescent display (VFD), a secondary microprocessor for control of the display, the display drivers, and front panel key matrix.

BNC board — a predominantly mechanical board which serves as a distribution point for control signals and AC power.

Micro-DIN board — a digital board which interfaces the rear panel Digital I/O and Trigger Link micro-DIN connectors to the digital board.

A switching-type power supply board furnishes +6VDC and +14.6VDC to the other boards and display.

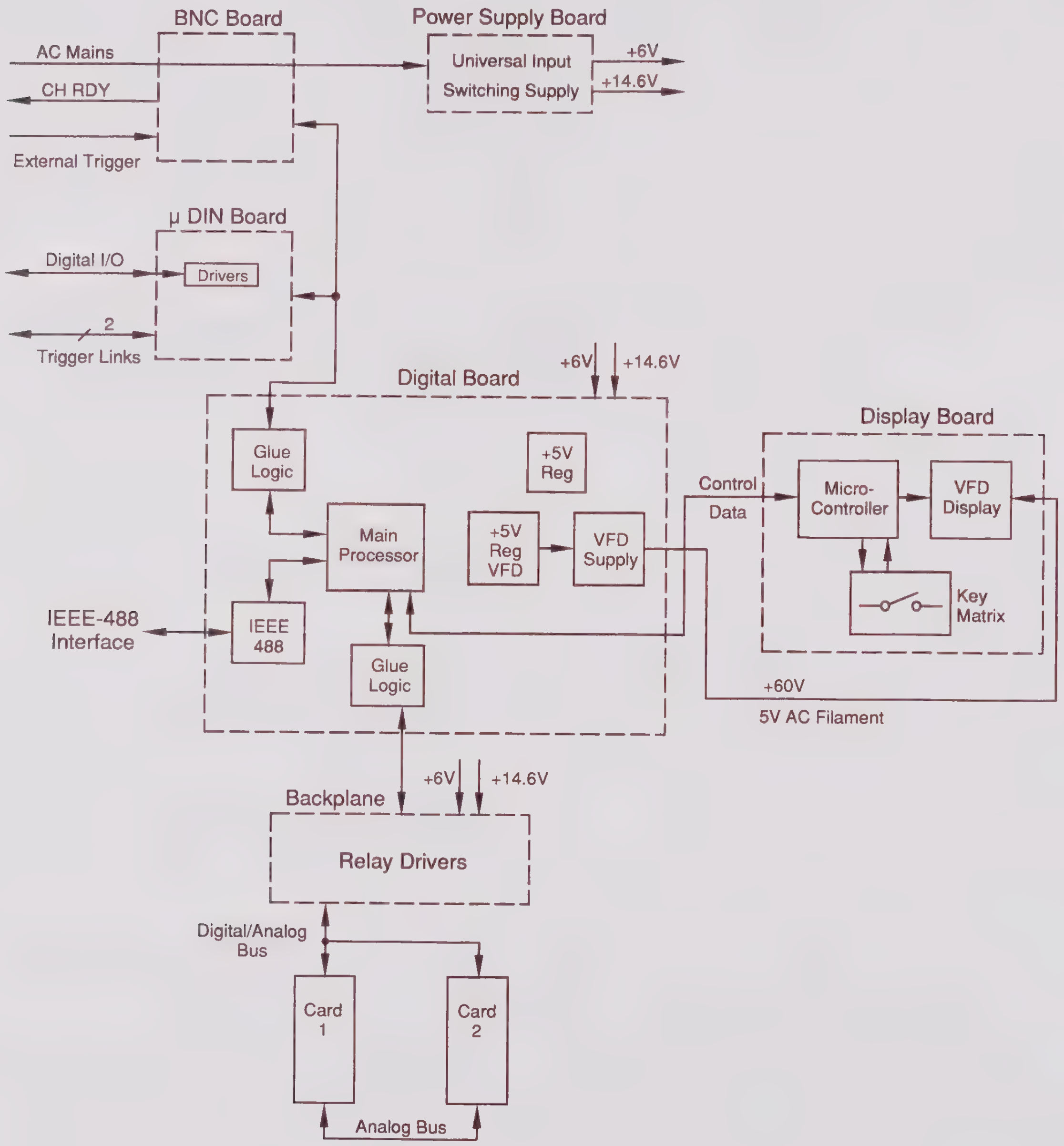

BNC Board
Power Supply Board
AC Mains
CH RDY
External Trigger
Universal Input
Switching Supply
+6V
+14.6V
µ DIN Board
Digital I/O
Drivers
2
Trigger Links
Digital Board
+6V
+14.6V
Glue Logic
+5V Reg
Main Processor
+5V Reg VFD
VFD Supply
IEEE-488 Interface
IEEE 488
Glue Logic
Display Board
Control
Data
Micro-Controller
VFD Display
Key Matrix
+60V
5V AC Filament
+6V
+14.6V
Backplane
Relay Drivers
Digital/Analog Bus
Card 1
Card 2
Analog Bus

Figure 6-1
Model 7001 system block diagram

6.3 Control function

The Model 7001 is controlled by two internal microprocessors. The primary controller resides on the digital board, and is responsible for supervising the overall operation of the Model 7001. The secondary controller is located on the display board and is primarily responsible for supervising operation of the display and keyboard and communicating with the main processor.

The primary controller consists of the following components:

- 68302 16-bit microprocessor
- 16MHz oscillator
- Power-up reset circuitry
- 128K × 16-bit EPROM
- Two 32K × 8-bit RAM with battery backup
- 2K × 8-bit EEPROM

The display microcontroller and associated components consist of the following:

- 68705 8-bit microcontroller
- 5812 and 5818 source drivers

6.3.1 Reset circuitry

For the following discussion, also refer to digital board schematic 7001-106.

Voltage supervision and monitoring is provided by a 7770-5 (U102) which checks for under-voltage conditions. On power-up, as Vcc approaches +1V, $\overline{\text{1RESET}}$ is active low. As Vcc approaches +3.5V, the time delay circuit of the 7770-5 activates, keeping $\overline{\text{1RESET}}$ low for an additional 200msec. When capacitor C146 (10μF) fully charges, $\overline{\text{1RESET}}$ then goes high. If Vcc falls below 4.55V, $\overline{\text{1RESET}}$ is reasserted low, and remains low until Vcc again exceeds 4.6V, and after the time delay has timed out.

$\overline{\text{1RESET}}$ is an open collector output which is tied to Vcc through a 470Ω resistor (R121). $\overline{\text{1RESET}}$ is tied to the RESET and HALT pins of the 68302 processor, each through a 560Ω resistor (R130 and R131). These two resistors enable the 68302 main processor to activate a reset condition in addition to when Vcc falls below 4.55V.

6.3.2 Address decoding

Address decoding is performed internally by the 68302 processor. No additional circuitry is required for this function.

6.3.3 Memory

For the following discussion, also refer to digital board schematic 7001-106.

The Model 7001's operating software is stored in U113, a 27C220 (128K × 16-bit) EPROM memory. The revision level of the software is displayed by the instrument upon power-up.

During system operation, relay setups, scan lists, forbidden channels, and other temporary storage tasks are accomplished through U110 and U111, which are 32K-byte static CMOS RAM chips. Power source and chip enable lines are routed through U108, a DS-1210 NVRAM controller. Figure 6-2 includes a simplified schematic of the RAM and battery back-up circuitry.

The NVRAM controller performs the functions of switching the RAM power source between Vcc and the lithium memory back-up battery BT100. It also disables the chip enable (CE) to the RAM when Vcc is outside the specified limits (see the previous information describing the reset circuitry).

If battery power drops below a specified limit while Vcc is not present, the DS-1210 chip (U108) disables the chip enable to the RAM after Vcc is restored. Then the CPU tries to read a special pattern in the RAM. If the CPU detects errors, it overrides the pattern and places the mainframe in a known state.

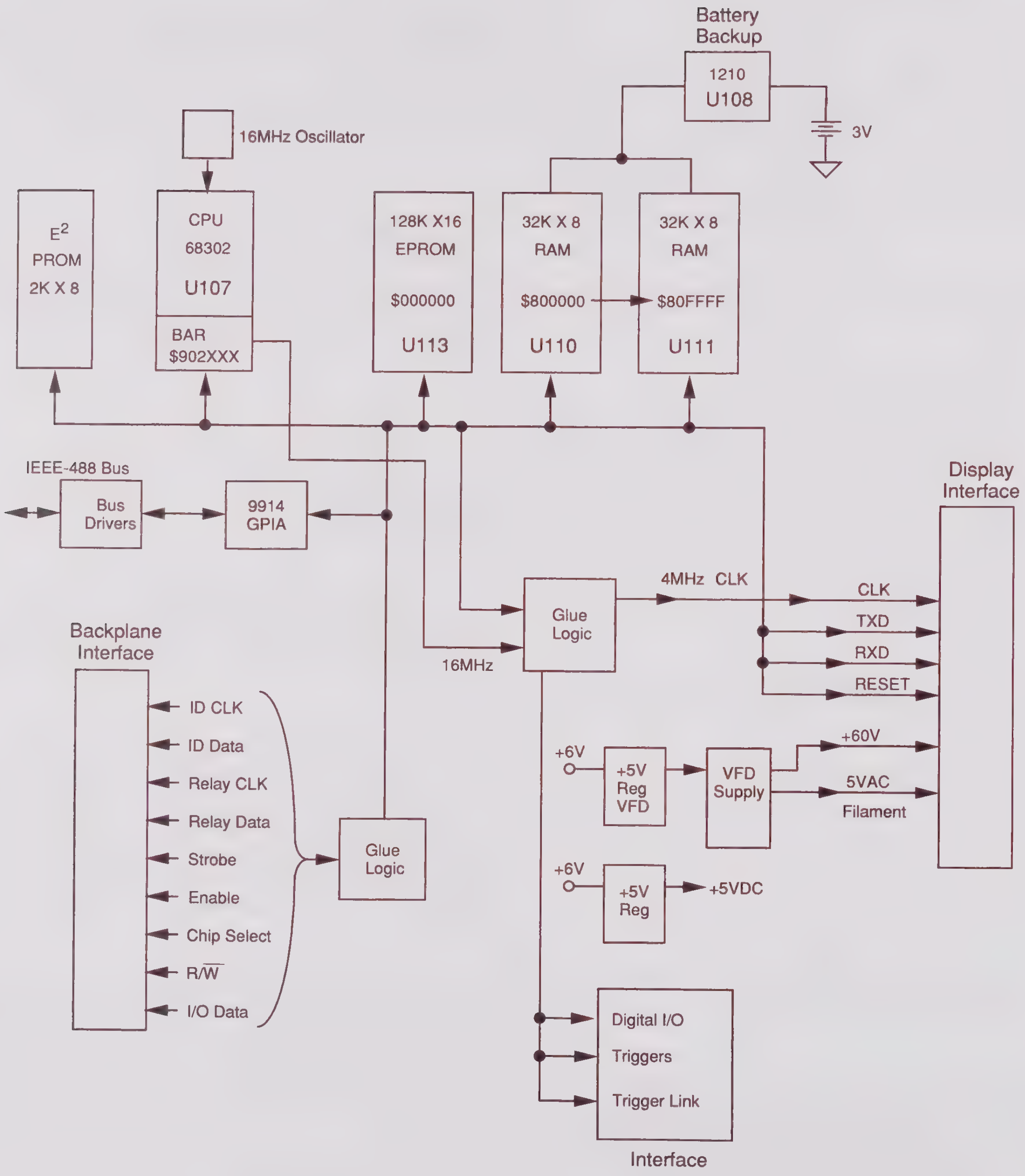

Battery Backup
1210
U108
3V
16MHz Oscillator
E2 PROM 2K X 8
CPU
68302
U107
BAR $902XXX
128K X16 EPROM
$000000
U113
32K X 8 RAM
$800000
U110
32K X 8 RAM
$80FFFF
U111
IEEE-488 Bus
Bus Drivers
9914 GPIA
Display Interface
Glue Logic
4MHz CLK
16MHz
CLK
TXD
RXD
RESET
Backplane Interface
ID CLK
ID Data
Relay CLK
Relay Data
Strobe
Enable
Chip Select
R/W
I/O Data
Glue Logic
+6V
+5V Reg VFD
VFD Supply
+60V
5VAC
Filament
+6V
+5V Reg
+5VDC
Digital I/O
Triggers
Trigger Link
Interface

Figure 6-2
Block diagram — digital circuitry and memory

6.4 Relay control circuitry

The relay control circuits collectively reside on the backplane card and each relay or matrix card assembly plugged into the Model 7001 mainframe.

The backplane board acts as a passive conduit for:

- Control signals from the digital board to the switch cards.
- Responses from the switch cards to the digital board.
- Power lines to the cards.
- Expansion of analog signals among the cards.
- Incorporation of relay drivers for the Model 705/706 switch cards.

The following paragraphs describe operation of the relay control circuitry on the digital board, as well as a typical matrix card. Also refer to backplane board schematic 7011-176.

6.4.1 Backplane interface

For the following discussion, consult Figures 6-3 and 6-4, which show a simplified schematic and timing diagram for the backplane interface.

During power-up, the main microprocessor reads card identification data via the backplane interface from the EEPROM on each switch card installed in the mainframe. The microprocessor also sends relay control data to the switch cards during the course of normal operation. The data is sent and received in serial form.

The serial data from the microprocessor has a common relay clock, ID clock, and relay data line that is multiplexed between the mainframe's slot 1 and slot 2 before being sent to the backplane. The multiplexing is controlled by line PB6 and $\overline{\text{PB6}}$. The remaining lines from the 68302 are buffered before terminating to the backplane interface.

At the start of a WRITE to a switch card, the 68302 internal registers are loaded with 5 bytes of information. PB6 is set to talk either to slot 1 or slot 2. The data is loaded on 40 clock cycles. At completion, the appropriate strobe line will go high and return low, latching the data into the backplane drivers and (if installed) the switch card drivers. On the first WRITE to the switch card, the enable line will go low, enabling the data in the register to be present on the output.

To start a READ cycle of a switch card, the user must be in the "CARD → READ-I/O-CARD" menu. This initializes the 68302 to allocate memory space to store I/O data. When in this menu, the STROBE signal will go high and return low, latching in data from the parallel-to-serial input register. Then, $\text{R}/\overline{\text{W}}$ and CS will be enabled along with 40 clock cycles, which are needed to read the I/O data. The ENABLE line will be active low after the first strobe pulse.

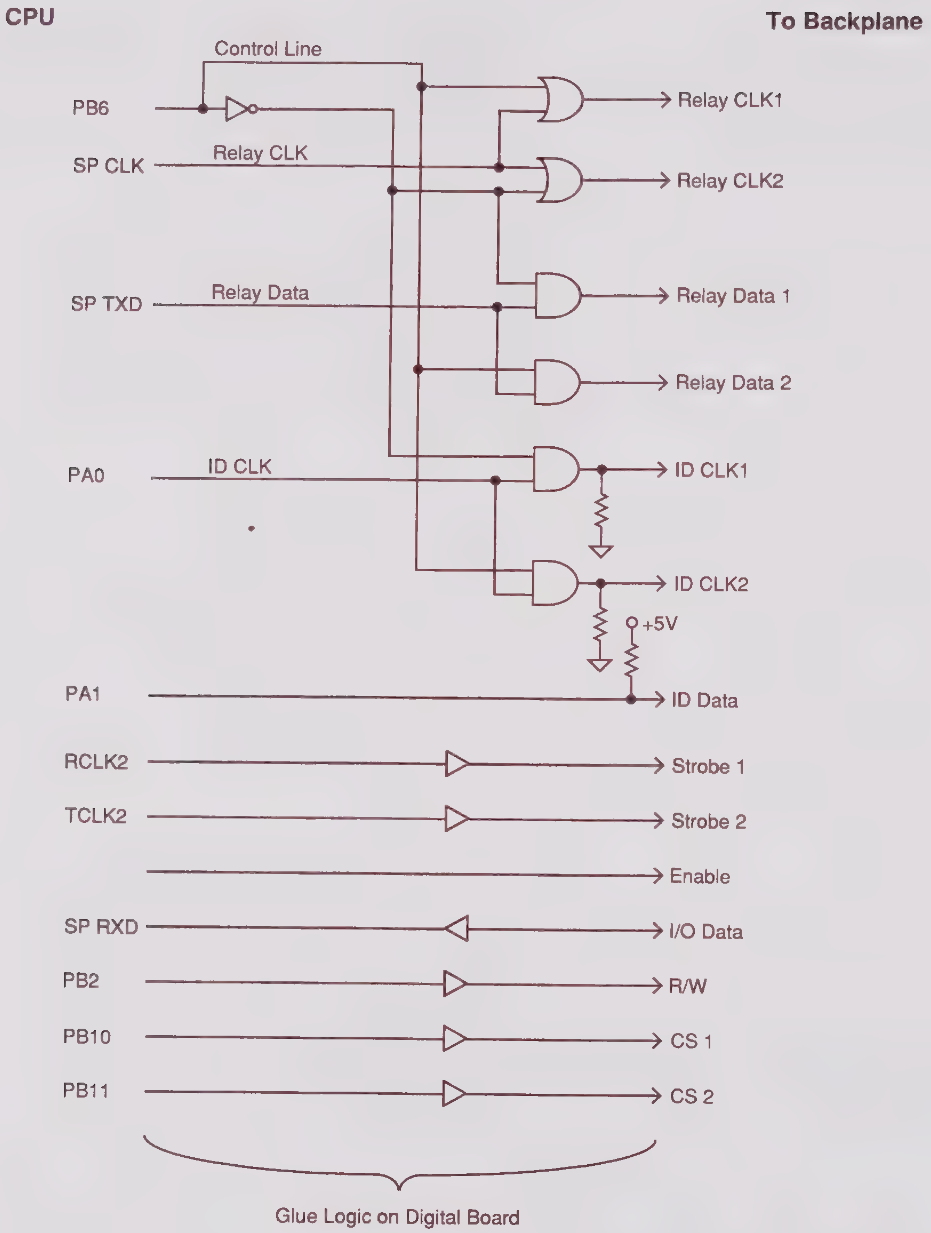
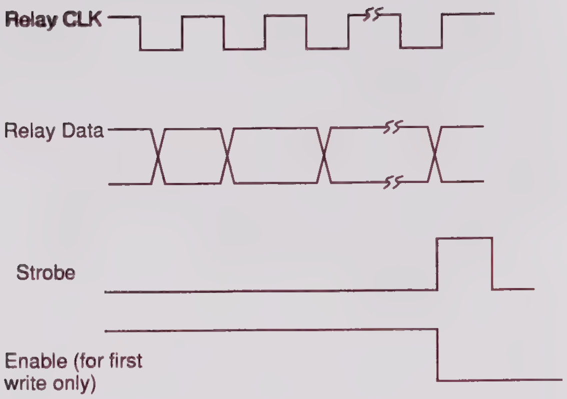
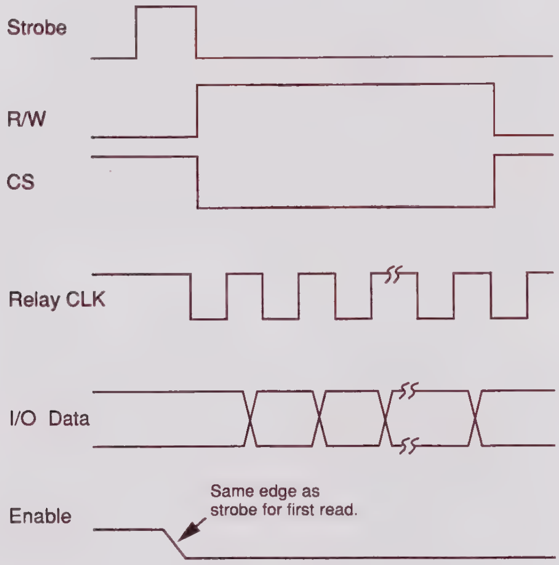

CPU
To Backplane
Control Line
PB6
SP CLK
Relay CLK
Relay CLK1
Relay CLK2
SP TXD
Relay Data
Relay Data 1
Relay Data 2
PA0
ID CLK
ID CLK1
ID CLK2
+5V
PA1
ID Data
RCLK2
Strobe 1
TCLK2
Strobe 2
Enable
SP RXD
I/O Data
PB2
R/W
PB10
CS 1
PB11
CS 2
Glue Logic on Digital Board

Figure 6-3
Backplane interface simplified schematic



A. Backplane Interface for Write Timing



B. Backplane Interface for Read Timing

Figure 6-4
Timing diagram — backplane interface WRITE

6.4.2 Switch card interface

The simplified block diagram of the backplane (Figure 6-5) shows two different switch card interfaces. One of these interfaces supports the Model 7052-7169 series switch cards while the other supports the Model 7011-7013 series switch cards.

The Model 7052-7169 switch card interface connectors J2000A/J2000B provide +6V, 12 sink drive lines, and a 3-line serial bus to support an additional 8 drive lines located on an installed switch card. This interface supports all Model 705 and 706 cards.

The Model 7011-7013 switch card interface connectors J2001A/J2001B provide +6V, +14.6V, +5V, a 4-line serial bus for relay driver communication, a 2-line serial bus for card identification, a 3-line serial bus for I/O data communication, and four 3-line analog bus expansions between slot 1 and slot 2. The serial bus communication supports 40 drive lines or 40 I/O lines on each installed switch card. This 32-pin DIN connector supports the Model 7011-7013 switch cards.

6.4.3 ID data circuits

Upon power-up, the mainframe reads card identification from any cards plugged into the mainframe. This ID data includes such information as card ID, hardware settling times, and relay configuration information.

ID data is contained within an EEPROM which is located on the relay card. The system performs the following sequence of operations at power-up in order to read the information:

1. The IDDATA line (pin 6 of the EEPROM located on the relay card) is set low while the IDCLK line (pin 5) is held high. This action initiates a start command for the ROM located on the relay card to transmit data serially to the mainframe (see Figure 6-6).
2. The mainframe sends the ROM address location to be read over the IDDATA line. The ROM then transmits an acknowledge signal back to the mainframe, and then transmits data at that location back to the mainframe (refer back to Figure 6-5).
3. The mainframe then transmits an acknowledge signal indicating that it requires more data. The ROM on the relay card will then sequentially transmit data after each acknowledge signal it receives.
4. Once all data are received, the mainframe sends a stop command. The stop command consists of a low-to-high transition of the IDDATA line while the IDCLK line is held high (see Figure 6-7).

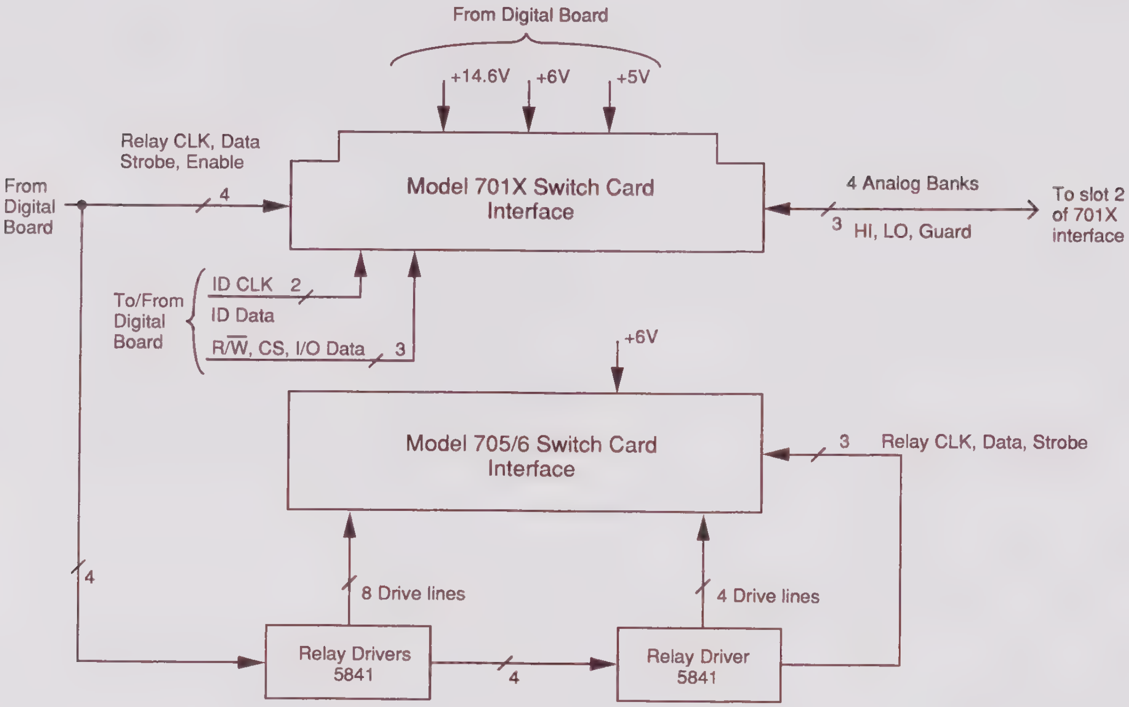

From Digital Board
+14.6V
+6V
+5V
Relay CLK, Data Strobe, Enable
From Digital Board
4
Model 701X Switch Card Interface
4 Analog Banks
3
HI, LO, Guard
To slot 2 of 701X interface
To/From Digital Board
ID CLK 2
ID Data
R/W̄, CS, I/O Data 3
+6V
Model 705/6 Switch Card Interface
3 Relay CLK, Data, Strobe
4
8 Drive lines
4 Drive lines
Relay Drivers 5841
4
Relay Driver 5841

Figure 6-5
Block diagram — backplane interface (one slot)

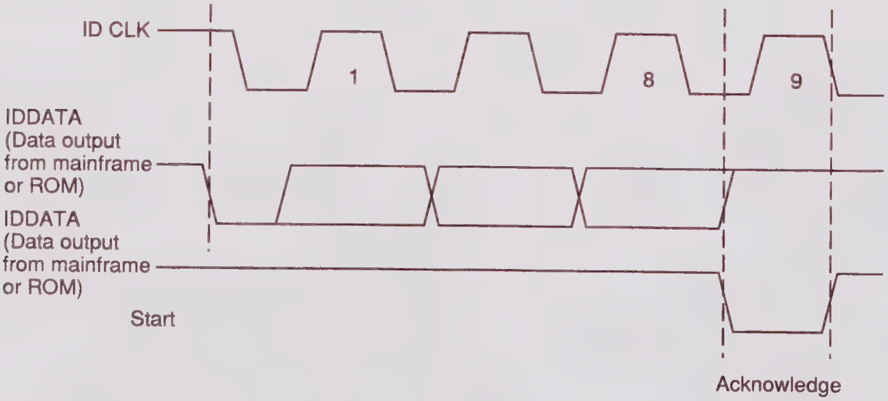

ID CLK
1
8
9
IDDATA (Data output from mainframe or ROM)
IDDATA (Data output from mainframe or ROM)
Start
Acknowledge

Figure 6-6
Timing diagram, IDCLK and IDDATA

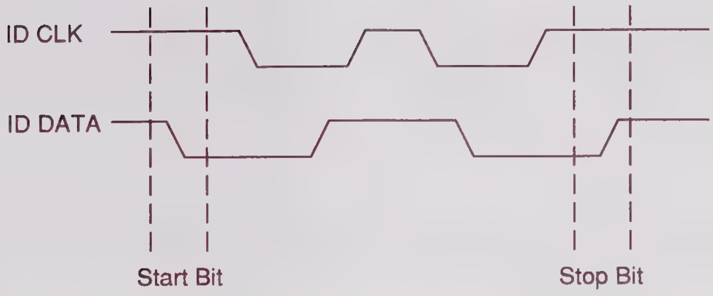


Figure 6-7
Start and stop sequences

6.4.4 Relay control

Card relays are controlled by serial data transmitted via the relay DATA line. Five bytes for each card are shifted in serial fashion into latches located in the card and backplane relay driver ICs. The serial data is clocked in by the CLK line. As data overflows one register, it is fed out the Q's line of the register down the chain.

Once all five bytes have been shifted into the drivers, the STROBE line is set high to latch the relay information into the Q outputs of the relay drivers. The appropriate relays are also energized (assuming the driver outputs are enabled, as discussed below). Note that a relay driver output goes low to energize the corresponding relay.

6.4.5 Power-on safeguard

A power-on safeguard circuit, consisting of U114 (a D-type flip-flop) and associated components, ensures that relays do not randomly energize on power-up and power-down. This circuit disables all relays to an open condition during power-up and power-down periods.

The PRESET line on the D-type flip-flop is controlled via the SYSRST line by the 68302 microprocessor, while the CLK line is controlled by a VIA port line from the 68302. The Q output of the flip-flop drives each switch card relay driver IC enable pin (U100-U104, pin 8).

When the 68302 microprocessor is in the RESET mode, the flip-flop PRESET line is held low, and the Q output immediately goes high, disabling all relays (the relay driver IC enable pins are high, disabling the relays). After the reset condition elapses (requiring approximately 200msec), PRESET goes high while the Q output stays high. With the first valid STROBE pulse, a low logic level is clocked into the D-type flip-flop, setting the Q output low and simultaneously enabling all relay drivers. Note that the Q output stays low (enabling the relay drivers), until the 68302 processor goes into a reset condition.

6.4.6 Display board circuitry

A block diagram of the display board is shown in Figure 6-8. Major components include the display microcontroller, the dot and grid drivers, the vacuum fluorescent display (VFD), and the key matrix.

The 68HC705 is the display microcontroller that controls the VFD and interprets key data. The microcontroller has four peripheral I/O ports, which are used for the various control and read functions. Display data is serially transmitted to the microcontroller from the digital board via the TXB line to the microcontroller PD0 terminal. In a similar manner, key data is serially sent back to the digital board through the RXB line via PD1.

Note that the 4MHz display clock is generated on the digital board.

The dual-line VFD (vacuum fluorescent display) module has a top line consisting of 20 alpha-numeric characters and annunciators. It is used to display patterns as well as text. The bottom line of the display is a 32-character alphanumeric, which is used to display text only.

Each character is organized as a 5 x 7 matrix of dots or pixels, and includes a long under-bar segment used as a cursor.

The display uses a common multiplexing scheme in which each character is refreshed in sequence. Dual UCN5812's are the dot drivers while a UCN5818 is the grid driver. The dot drivers and grid drivers are serially transmitted from PD3 and PC1, respectively. The clock for the dot drivers is from PD4 of the microcontroller, while the clock for the grid driver is taken from PC0 of the microcontroller.

The VFD requires both +60VDC and +5VAC for the filaments. These VFD voltages are supplied by U117, which is located on the digital board.

The front panel keys are organized into a row-column matrix to minimize the number of microcontroller peripheral lines required to read the keyboard. A key is read by strobing the columns and reading all rows for each strobed column. Keypress data is interpreted by the display microcontroller and sent back to the main microprocessor using proprietary encoding schemes.

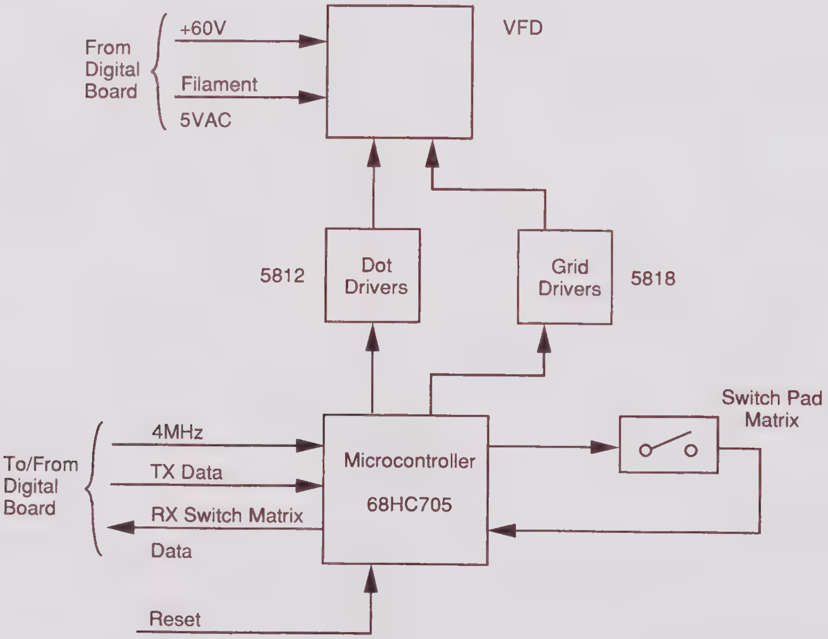

From Digital Board
+60V
Filament
5VAC
VFD
5812
Dot Drivers
Grid Drivers
5818
Switch Pad Matrix
To/From Digital Board
4MHz
TX Data
RX Switch Matrix
Data
Microcontroller
68HC705
Reset

Figure 6-8
Display board block diagram

6.4.7 External control signals

For the following discussion, refer to BNC board schematic 7001-166 and micro-DIN board schematic 7001-186.

External signals are CHANNEL READY and EXTERNAL TRIGGER, as shown in Figure 6-9, and DIGITAL I/O, as shown in Figure 6-10.

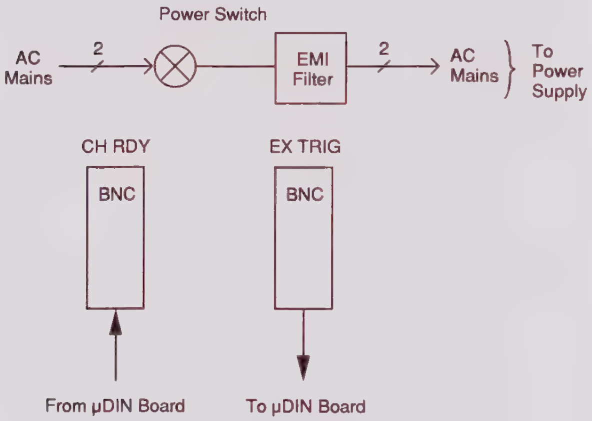


Figure 6-9
BNC board block diagram

CHANNEL READY and EXTERNAL TRIGGER are TTL-compatible, and support communication with existing instrument products or other user-supplied equipment through BNC connectors.

TRIGGER LINK consists of six TTL-compatible signals that can be bused between instruments via a pair of 8-pin TRIGGER LINK IN and TRIGGER LINK OUT micro-DIN connectors located on the Model 7001 rear panel. The TRIGGER LINK can be programmed in asynchronous mode to operate as an additional CHANNEL READY or EXTERNAL TRIGGER signal, or in semi-synchronous mode.

DIGITAL I/O has four programmable outputs, one TTL output, and an additional line that provides external pull-up voltage for the outputs. DIGITAL I/O is provided through a third 8-pin micro-DIN connector located on the Model 7001 rear panel.

All external control signals can be controlled through the front panel or programmed via the IEEE-488 bus.

6.4.8 IEEE-488 interface

The IEEE-488 interface is composed of three ICs. A 9914 General-Purpose Interface Adapter (GPIA) automatically performs many bus control, data I/O, and handshaking functions, thus minimizing overhead to the system microprocessors. Bus drive capabilities are provided by a 75161 and 75160 (U100 and U101). The 75161 supports bus management and handshake lines, while the 75160 drives the data lines.

6.4.9 Power supplies

The major component of the power supply is a universal AC-input switching power supply. This supply contains an internal line fuse and an autoranging input which automatically adjusts to the voltage of the input mains. The power switch is located on the BNC board, and actuated from the front panel through a mechanical extension of the ON/OFF button. The AC input receptacle is also wired to the BNC board; from here it is passed directly to the power supply board.

The switching supply provides regulated +6VDC and +14.6VDC for the relay power supply circuitry. These voltages are routed to the switch card via the digital board and backplane. On the digital board, the +6V is regulated to +5V using two LM2940 regulators. One LM2940 supplies +5V to the digital display, backplane, switch cards, and micro-DIN boards, while the other LM2940 provides +5V to U117, the VFD supply module. The VFD supply module generates +60VDC and 5VAC for the display board.

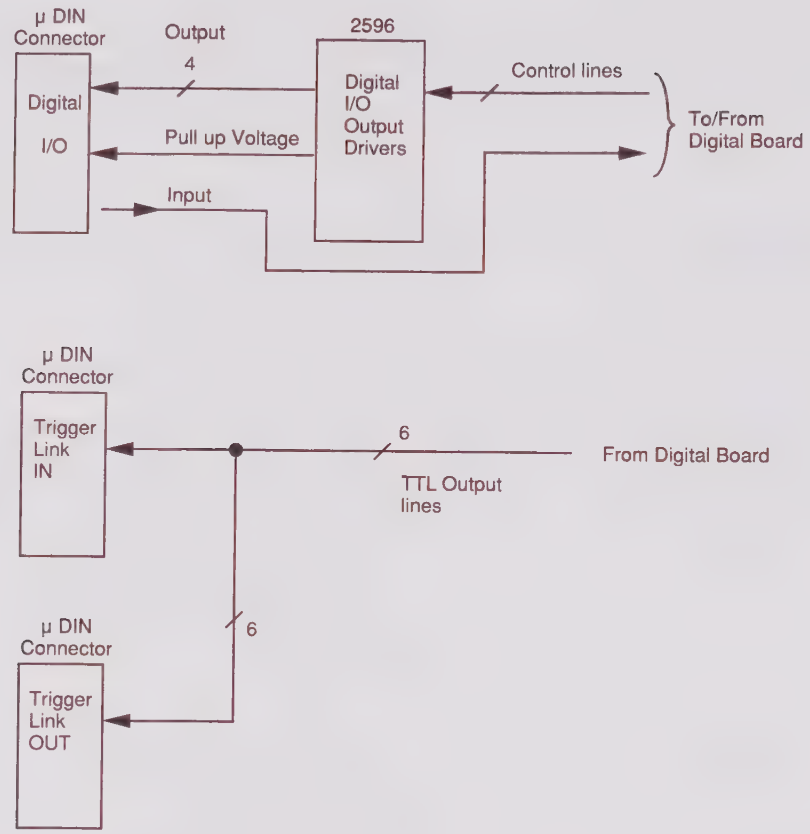

μ DIN Connector
Digital I/O
Output
4
2596
Digital I/O Output Drivers
Control lines
To/From Digital Board
Pull up Voltage
Input
μ DIN Connector
Trigger Link IN
6
From Digital Board
TTL Output lines
μ DIN Connector
Trigger Link OUT
6

Figure 6-10
Micro DIN board block diagram

7

Maintenance

7.1 Introduction

This section of the manual will assist you in performing maintenance and troubleshooting of the Model 7001.

WARNING

The information in this section is intended for qualified service personnel. Some of these procedures may expose you to hazardous voltages. Do not perform these procedures unless you are qualified to do so.

Section 7 includes the following:

7.2 **Service options:** Suggests courses of action for obtaining service.

7.3 **Static-sensitive devices:** Covers precautions necessary when handling static-sensitive parts.

7.4 **Routine maintenance:** Describes normal maintenance items which you may expect to perform during the life of the instrument.

7.5 **Disassembly:** Describes removal of the case and circuit boards from the instrument.

7.6 **Diagnostics:** Describes running the built-in tests of the circuitry and display.

7.7 **Test descriptions and notes:** Provides details on the diagnostic tests plus additional information to assist you in isolating problems.

7.8 **Troubleshooting:** Outlines a series of additional checks and tests which may be used to diagnose malfunctions.

7.2 Service options

You have several options for maintenance and repair of the Model 7001. The choice will depend upon your ability to diagnose the problems, as well as your repair facilities:

1. You may return the entire instrument to Keithley.
2. If you have the necessary equipment and expertise, you may perform your own routine maintenance.
3. If repairs are needed and you can isolate a failure to a specific circuit board, you may contact Keithley to obtain a replacement for the board. Troubleshooting and diagnostic procedures in this section are designed to help pinpoint problems to the board level.

NOTE

The digital and display boards are built using surface mount techniques, and require specialized equipment and skills for repair. Keithley recommends that these repairs be referred to the factory. The backplane, micro DIN, BNC, and power supply boards use conventional assembly techniques and can be repaired at the component level, but board replacement is still recommended.

Without proper tools or training, you may inflict further damage which cannot be repaired at the factory. Such damages may void the warranty.

7.3 Handling and cleaning

7.3.1 Backplane board

Row signal paths for Model 701X series switching cards are extended onto the backplane boards of the mainframe. Thus, a contaminated backplane will degrade card isolation specifications. If an isolation problem is due to a contaminated backplane, then the backplane board will have to be removed and cleaned. Paragraph 7.5.2 explains how to remove the backplane board.

Handling backplane board

Observe the following precautions when handling the backplane board:

- Handle the board only by the edges.
- When servicing the board, wear clean cotton gloves.
- Do not touch any board traces or components not associated with the repair.
- Do not touch areas adjacent to electrical contacts.
- Use dry nitrogen gas to clean dust off the board.

Solder repairs and cleaning

- Use an OA-based (organic activated) flux, and take care not to spread the flux to other areas of the board.
- Remove the flux from the work areas when the repair has been completed. Use pure water along with clean foam-tipped swabs or a clean soft brush to remove the flux.
- Once the flux has been removed, swab the repaired area (or contaminated area) with methanol, then blow dry the board with dry nitrogen gas.
- After cleaning, the board should be allowed to dry in a 50°C low-humidity environment for several hours.

7.3.2 Static-sensitive devices

CMOS devices are designed to operate at high impedance levels for lower power consumption. As a result, any static charge that builds up on your person or clothing may be sufficient to destroy these devices if they are not handled properly. Use the precautions below when handling static-sensitive devices:

CAUTION

Many CMOS devices are installed in the Model 7001. Generally, all ICs and transistors should be handled as static-sensitive devices.

1. Transport such devices only in containers designed to prevent static build- up. Typically, these parts will be received in anti-static containers of plastic or foam. Always leave the devices in question in their original containers until ready for installation.
2. Remove the devices from their protective containers only at a properly grounded work station. Also, ground yourself with a suitable wrist strap.
3. Handle the devices only by the body; do not touch the pins or terminals.
4. Any printed circuit board into which the device is to be inserted must also be properly grounded to the bench or table.
5. Use only anti-static type de-soldering tools.
6. Use only soldering irons with properly grounded tips.
7. Once the device is installed on the PC board, it is usually adequately protected, and normal handling can resume.

7.4 Routine maintenance

The following procedures summarize routine maintenance for the Model 7001. These procedures require disassembly of the instrument (also see paragraph 7.5).

7.4.1 Line voltage selection

The Model 7001 power supply board automatically adjusts to line voltage and frequency. There are no internal switches for this purpose.

7.4.2 Changing the fuse

WARNING

Disconnect the instrument from the power line and all other equipment before replacing the line fuse.

The Model 7001 uses a single fuse which is mounted on the power supply board. This board is located on the underside of the instrument, immediately beneath the power switch pushrod.

Replacement of the fuse requires removal of the instrument case. The snap-in fuse can be replaced without removing the power supply board.

If the fuse should fail, try to determine the cause before installing the replacement. The correct fuse type is as follows:

Line voltage	Type	Rating
All	5 × 20mm	250V, 2A - Fast Blow

CAUTION

Use only the specified fuse type, or instrument damage may occur.

7.4.3 Changing the battery

WARNING

Disconnect the instrument from the power line and all other equipment before changing the battery.

The volatile memories in the Model 7001 are protected by a replaceable battery when power is off. Typical life for the battery is approximately ten years. This battery should be suspected if the instrument no longer retains scan lists or other user-programmed operating parameters. If the battery is absent or totally exhausted, the display will show the message “No Comm Link” shortly after the Model 7001 is switched on. (This is just one of the causes of the “No Comm Link” message. See paragraphs 7.7.1 and 7.8.1 for more causes.)

The battery is a 3V wafer-type lithium cell, Duracell type DL2450 or equivalent (Keithley part number BA-44), which is located on the digital board.

Replacement of the memory back-up battery requires removal of the instrument case, followed by removal of the digital board and its shield. (See paragraph 7.5 for the disassembly procedure.)

WARNING

The precautions below must be followed to avoid possible personal injury.

1. Wear safety glasses or goggles when working with lithium batteries.
2. Do not short the battery terminals together.
3. Keep lithium batteries away from all liquids.
4. Do not attempt to recharge lithium batteries.
5. Observe proper polarity when inserting the battery into its holder.
6. Do not incinerate or otherwise expose the battery to excessive heat (>60°C).
7. Bulk quantities of lithium batteries should be disposed of as a hazardous waste.

To replace the battery, first locate its holder (labeled BT100). Use a small non-metallic tool to lift the battery so that it can be slid out from under the retainer spring clip.

The new battery should be reinstalled with the "+" terminal facing up. Lift up on the retaining clip and place the edge of the battery under the clip. Slide the battery fully into the holder. Recheck previously stored settings and re-enter the configuration as necessary.

7.4.4 Changing firmware

WARNING

Disconnect the instrument from the power line and all other equipment before changing the firmware.

Changing of the firmware is not a routine maintenance item, but may be necessary as upgrades become available. The firmware revision levels of the main CPU and display CPU are displayed briefly on the front panel when the Model 7001 is switched on.

The firmware for the main CPU is located in EPROM U113, a leadless IC which resides in a chip carrier on the digital board.

Replacement of the main CPU firmware requires removal of the instrument case, followed by removal of the digital board and its shield.

Removal and replacement of the firmware EPROM should be performed only by qualified personnel using appropriate IC extraction tools.

7.5 Disassembly of the instrument

Normal maintenance of the Model 7001 requires removal of the instrument cover. Further disassembly should only be required for repair.

WARNING

Disconnect the power cord from the rear of the instrument and allow several minutes for any energy stored in the power supply or other circuits to bleed off before opening the instrument. Also, remove the IEEE-488 cable and any boards plugged into the Model 7001 backplane.

NOTE

If the Model 7001 has been rack mounted, the feet, handle, and handle mounting ears will have been replaced by rack mount hardware. If so, modify the disassembly and assembly instructions accordingly.

For the following procedures, you will require a #2 Phillips screwdriver with a 4-inch shaft and a flat-bladed pocket screwdriver.

Generally, assembly is the reverse order of disassembly. Some items, such as the handle, case, rear bezel, and internal cabling, can be properly reinstalled only one way. Make note of the orientation of any items which you remove.

7.5.1 Removal of the case

Refer to drawing 7001-054 Final Chassis Assembly at the end of this section.

1. Set the Model 7001 on a flat surface, resting on its bottom.
2. Grasp the handle at each pivot point where it attaches to the sides of the instrument. Simultaneously pull both sides of the handle gently outward, away from the instrument. While maintaining outward pressure on the sides of handle, swing the handle fully below the bottom surface of the case. At the point where the arrows on the handle line up with the arrows on the mounting ears, the sides of the handle can be separated slightly more, permitting the handle to be completely removed.

3. Remove the screws concealed in the handle mounting wells on each side of the instrument.
4. Lift the front end of the instrument slightly and remove the mounting ears by pulling each downward approximately 1/8" (3mm).
5. Loosen the two mounting screws at the rear bezel of the instrument. These screws are held captive in the bezel, and cannot be removed completely. When both screws are fully loosened, remove the rear bezel.
6. Remove the instrument's grounding screw located on the bottom side of the Model 7001.
7. Grasp the front bezel of instrument and carefully slide the chassis forward, out of the metal case.

The internal board assemblies of the Model 7001 are now accessible.

7.5.2 Removal of individual boards

Individual boards within the Model 7001 may now be removed as needed. Removal of some boards requires prior removal of other boards.

CAUTION

Some boards use mass termination connectors which mate directly to adjacent boards. Reinstallation of these boards requires extra attention to align pins and avoid mechanical damage.

NOTE

Keep track of screws and other fasteners which you may remove. Some boards are held in place with a combination of long and short screws, or other types of fasteners which must be reinstalled in the proper positions. The boards in the Model 7001 are interconnected using a variety of cables and terminations. As you disassemble the instrument, make note of positions and keying of terminations to assure correct reattachment.

Micro DIN board removal

Removal of the micro DIN board does not require removal of any other boards. Refer to drawing 7001-053 Chassis Assembly at the end of this section.

To remove the micro DIN board:

1. Disconnect the cable which connects the micro DIN board to the BNC board.
2. Remove the screw which holds the micro DIN board to the chassis.
3. The micro DIN board is now held in position only by a mass termination connector which mates to the underside of the digital board. Carefully pull the micro DIN board straight out of the chassis to separate it from the digital board.

Assembly note: When you reinstall the micro DIN board, take care not to bend any pins on this connector.

Power supply removal

Removal of the power supply board does not require removal of any other boards. Refer to drawing 7001-052 Digital Board/Chassis Assembly at the end of this section.

The power supply board is located on the underside of the instrument, immediately forward of the micro DIN and BNC boards. It is covered by a flexible insulating shield which must be folded back to access the power supply connectors and mounting screws. The power switch is located on the BNC board, and actuated by a rod which protrudes through the front panel as the ON/OFF switch button.

WARNING

Disconnect the instrument from the power line and all other equipment before removing the power supply.

To remove the power supply:

1. Disconnect the power connectors from the forward and rear ends of the power supply board.
2. Remove the pushrod:

   A. With a flat-bladed pocket screwdriver, gently pry the pushrod forward where it connects to the power switch.
   B. Gently lift the pushrod up, out of the power switch.
   C. Pull the pushrod back toward the AC line input and out of the front panel.
3. Locate the three mounting screws and one nylon stand-off which hold the power supply board to the chassis.
4. Remove the three mounting screws. Note that the two screws nearest the side panel of the chassis are long screws which also fasten the digital board to the chassis.
5. Carefully pry the power supply board away from the nylon stand-off using a non-metallic tool. With gentle pressure, the power supply board will snap free of the stand-off and can be removed.
6. Carefully lift the power supply board from the instrument.

Assembly note: When reinstalling the power switch pushrod, insert the pushrod through the front panel, then connect it to the power switch. (See drawing 7001-053 at the end of this section.) When viewed from the front of the unit, ensure that the POWER button is in the outer (OFF) position before continuing assembly.

Front panel removal

Removal of the front panel does not require removal of any other boards. Refer to drawings 7001-054 Final Chassis Assembly and 7001-040 Front Panel Assembly at the end of this section.

The front panel unit is an assembly of the front panel bezel, display board, and keyboard assembly. It is held in position by two plastic tabs on each side of the front panel unit which engage two metal studs located on each side of the chassis. The display itself is connected to the digital board through a 16-conductor ribbon cable which feeds through a rectangular hole in the front bulkhead.

To remove the front panel unit:

1. First pull the ribbon cable termination from its receptacle on the digital board.
2. Gently pry open the plastic strain relief that holds the ribbon cable.
3. Gently pry up on both plastic tabs which hold one end of the front bezel to the chassis, and slide the bezel forward slightly to free the tabs. Repeat this procedure for the other side of the bezel.

CAUTION

Take care to lift the tabs only far enough to free the bezel. Excess force will break the tabs.

4. When the front bezel has been freed, remove the front panel assembly with ribbon cable.
5. The front panel unit can be further disassembled to remove the display board if necessary. Locate the plastic retaining bar located at the bottom inside edge of the bezel. Carefully pop the bar away from the bezel. Afterward, the display board can be removed from the bezel.
6. The keyboard pushbuttons can now be removed from the front panel. These are installed as one or two multi-key overlays. The overlays are captured by wells located in the inside of the front panel.

BNC board removal

Removal of the BNC board requires that the power switch pushrod first be removed. If necessary, refer back to removal of the power supply (step 2). Also, refer to drawing 7001-053 Chassis Assembly at the end of this section.

To remove the BNC board:

1. Confirm that the pushrod has been removed.
2. Disconnect the cable which connects the micro DIN board to the BNC board.
3. Disconnect the AC power feed from the BNC board.
4. Loosen and remove the nuts and washers which fasten the two BNC connectors to the rear panel.
5. Slide the BNC board toward the front of the unit until the board slot aligns with the chassis lance, then lift the board free of the chassis.

Digital board removal

Before the digital board and shield can be removed, the micro DIN board must be removed. Refer to the previous instructions for removing this item, and then proceed with the following steps. Also, refer to drawing 7001-052 Digital Board/Chassis Assembly at the end of this section.

1. Confirm that the micro DIN board has been removed.
2. If the power supply board is still in position, locate the two power supply mounting screws nearest the side of the instrument. These screws extend into the digital board. Remove these two screws.
3. If necessary, disconnect the power and display connectors from the forward edge of the digital board.
4. Remove the two mounting nuts from the IEEE-488 connector on the rear panel of the instrument.
5. Note that the digital board is now held in position only by the mass termination connector P1004 which mates the digital board to the backplane board. Carefully slide the digital board/shield assembly forward until the pins of this connector are free.
6. Slide the digital board/shield assembly to the side to remove it from the chassis.
7. To further disassemble the digital board/shield assembly, remove the two screws which fasten the shield to the digital board, then remove the shield from the board.

CAUTION

Do not operate the Model 7001 with the digital board shield removed for an extended period of time, because the shield acts as a heat sink for one of the +5V regulators.

Assembly notes: Since the shield acts as a heat sink for one of the +5V regulators, ensure that the shield standoff properly aligns with the regulator when re-assembling.

When reinstalling the digital board/shield assembly, position the digital board in the chassis and then slide it back to engage P1004 on the digital board into the mating socket on the backplane board.

Install and tighten the mounting screws in the IEEE-488 connector. Align the pins of the micro DIN board with the digital board, seat the micro DIN board, and replace its retaining screw.

Install and tighten all other screws which fasten the digital board to the chassis.

Backplane board removal

Before the backplane board can be removed, the micro DIN, front panel, and digital boards must be removed. Refer to the previous instructions for removing these items, and then proceed with the following steps. Also, refer to drawings 7001-052 Digital Board/Chassis Assembly, 7001-051 Card Cage/Chassis Assembly, and 7001-050 Card Cage Assembly at the end of this section.

1. Confirm that the micro DIN board, front panel, and digital board have been removed.
2. Locate and remove the four mounting screws which fasten the backplane board to the chassis. These can be removed using a long screwdriver inserted through the four access holes on the front bulkhead of the chassis.
3. Carefully lift the backplane board assembly out of the chassis.

7.5.3 Replacement of the case

Refer to 7001-054 Final Chassis Assembly at the end of this section.

1. Reinstall any boards you have removed from the Model 7001. If disassembly has been extensive, temporarily reattach the power cable and turn on the unit to confirm proper operation of the instrument before you replace the case. Remove the power cable again before proceeding.
2. Carefully insert the rear of the instrument into the front of the metal case. Slide the instrument fully into the case, and engage the tabs on the forward edge of the metal case into the slots on the rear edge of the front bezel.
3. Reinstall the ground screw on the bottom side of the Model 7001.
4. Install the rear bezel and tighten the rear bezel mounting screws completely.
5. Install the left and right handle mounting ears: Place a proper mounting ear over the rectangular opening on the side of the instrument, near the front bezel. Slide the handle mount upward approximately $^1/_8$" (3 mm) to engage the tabs on the handle mount into the case, and align the screw holes. Install the retaining screw.
6. Install the handle: Grasp the handle at its sides and gently pull the ends of the handle slightly away from each other. Insert the handle into the handle mounts at the point where the arrows on the handle line up with the arrows on the mounting ears. Release pressure slightly, and rotate the handle until it snaps to rest in the desired position. The han-

dle will lock in three positions: fully retracted under the instrument, plus 90° and 180° from this position.

CAUTION

The handle parks over the top surface of the case. Do not attempt to carry the instrument by the handle when the handle is in this position. The handle may accidently come free, allowing the instrument to fall and be damaged.

7.6 Diagnostics

The Model 7001 includes a series of on-board diagnostic tests which may be invoked through the front panel and performed without any disassembly of the instrument. These diagnostics will help verify functionality of the Model 7001, and will assist you in isolating problems to the board level.

7.6.1 Preparations for running the diagnostics

Before running the diagnostic tests:

1. Power down the Model 7001.
2. Disconnect the IEEE-488 cable and any BNC or trigger cables from the rear panel.
3. Remove any cards which may be plugged into the backplane. (Note that card removal is not necessary for the non-volatile memory test.)

NOTE

Some tests, notably the IEEE-488 interface tests, may incorrectly indicate a failure if run with cables connected.

7.6.2 Initial power-up test

Install a line cord and apply power. The Model 7001 should sequence through ROM revision levels, IEEE-488 address and card configurations as described in the operating sections of this manual.

On power-up, the Model 7001 will show "#1 = NONE #2 = NONE" indicating that no cards are installed in either card slot.

NOTE

If Model 705/706 cards had been previously programmed in the Model 7001, the power-up message will still show them present.

7.6.3 Non-volatile memory test

1. Press CARD CONFIGURATION.
2. Under the CARD CONFIG MENU, select TYPE and press ENTER.
3. Under the SET CARD TYPE menu, select SLOT-1 and press ENTER.
4. Press the ◁ or ▷ cursor keys until the display shows:

```
SLOT-1 CARD: 9990
```

then press ENTER.

5. Press the EXIT key until the display shows SELECT CHANNELS. This programs the setup memory for a generic 40-channel scanner card (9990).
6. Press the SCAN LIST key.
7. Press the CLEAR LIST key.
8. Press "1", "1", ENTER. The display should show:

```
SCAN-CHANNELS 1!1,
```

This programs a scan list which should be retained in battery backed up RAM. After programming setups, the Model 7001 must retain these assignments when power is switched off, or until reprogrammed.

9. Turn off power and wait a few minutes.
10. Turn on power. Verify "#1 = 9990" in the power-up display.
11. Press SCAN LIST. Verify:

```
SCAN CHANNELS 1!1,
```

If the Model 7001 does not retain the settings, one of the following problems may exist:

- Failure to retain the card number 9990 indicates a fault with EEPROM.
- Failure to retain the SCAN LIST indicates a fault with battery backed up RAM.

7.6.4 Built-in-tests

The Model 7001's main circuitry can be verified through the use of the "Built-In-Tests" (BIT). The BIT can be executed in automatic or manual modes. Manual mode can be used to execute individual tests, or to cycle tests indefinitely for specialized troubleshooting.

Automatic test mode

Automatic testing provides a quick scan of most major Model 7001 circuit blocks, and can be invoked using the following steps:

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the TEST MENU, select BUILT-IN-TESTS and press ENTER.
4. Under BUILT-IN-TESTS, select AUTO and press ENTER.
5. Under CONTINUOUS REPEAT?, select NO and press ENTER. This will run the test once. For continuous cycling of the tests, select CONTINUOUS, and press ENTER. The tests will execute until you press EXIT. Automatic continuous mode may be used to scan for intermittent faults.

As the tests cycle, the display will show the message:

```
NNN.NN Running A or
NNN.NN Running AC
```

where "A" signifies "Automatic", "AC" signifies "Automatic/Continuous", and NNN.NN is the number of the test being run.

At the conclusion of successful testing, the display should indicate no faults:

```
All tests complete
Press any key to continue
```

If a test fails, an asterisk "*" will appear in the top line of the display, and the second line will advise on further steps:

```
All tests complete *
Press ENTER to review or EXIT
```

To review the error, press ENTER. The display will show the test which failed. For further information on the failure, press INFO. A detailed description of BIT faults may be found later in this section.

Manual test mode

Manual testing permits execution of individual Built-In-Tests options to help isolate faults. The BIT may be executed in manual mode as follows:

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the TEST MENU, select the BUILT-IN-TESTS option and press ENTER.
4. Under the BUILT-IN-TESTS menu, select MANUAL option and press ENTER.
5. Press the ◁ and ▷ cursor keys to select the desired test number, then press ENTER to invoke the test. The INFO key can be pressed for a short description of any test function.
    - 100 — EPROM test
    - 101 — RAM test
    - 102 — EEPROM test
    - 103 — Digital I/O:
      103.1-103.4 — Digital Output bits 1-4
      103.5 — Digital Input
    - 104 — IEEE-488 test
      104.1 — Handshake Test
      104.2 — IEEE-488 Data
    - 105 — Trigger tests
      105.1-105.6 — System Trigger Bus
      105.7 — External Trigger/Channel Ready
      105.8 — Group Execute Trigger (GET)
      105.11-105.18 — Trigger Shorts tests

6. Select the SINGLE, CONTINUOUS, or STEP mode, and press ENTER to invoke the desired mode:
   - SINGLE — Runs the selected test once.
   - CONTINUOUS — Runs the selected test repeatedly.
   - STEP — Runs the test once, pausing after each test sub-section.
7. As the tests cycle, the display will show the message

   NNN.NN Running M or
   NNN.NN Running MC or
   NNN.NN Paused MS

   where "M" signifies "Manual", "MC" signifies "Manual/Continuous", "MS" signifies "Manual/Step", and NNN.NN is the number of the test being run.

In the STEP mode, press ENTER to move through the individual tests.

At the conclusion of successful testing the display should indicate no faults:

```
All tests complete
Press any key to continue
```

If a test fails, an asterisk "*" will appear in the top line of the display, and the second line will advise on further steps:

```
All tests complete *
Press ENTER to review or EXIT
```

To review the error, press ENTER. The display will show the test which failed. For further information on the failure, press INFO. A detailed description of BIT faults may be found later in this section.

7.6.5 Display test — keys

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the TEST MENU, select the DISPLAY-TESTS option and press ENTER.
4. Under DISPLAY-TESTS, select KEYS and press ENTER. The display will show "No keys pressed".
5. Press each key (except POWER) in turn and verify that the corresponding key name is displayed.
6. Verify that the display returns to "No keys pressed" when each key is released, i.e., no sticking keys.
7. When you are done with the key test, press EXIT twice to exit.

7.6.6 Display test — patterns

The display PATTERNS test is a visual check of the vacuum fluorescent display (VFD) module. See Figure 7-1.

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the TEST MENU select the DISPLAY-TESTS option and press ENTER.
4. Under DISPLAY-TESTS select PATTERNS and press ENTER.
5. This displays five test patterns:

Pattern screen 1

A checkerboard pattern of 18 dots appears for all 20 characters in the top row and 32 characters in the bottom row. The annunciators will be shown as in Figure 7-1.

Pattern screen 2

The alternate checkerboard pattern of 17 dots appears for all 20 characters in top row and 32 characters in the bottom row. The annunciators disappear and are replaced by the numbers:

1 2 3 4 5 6 7 8 9 10

Pattern screen 3

A horizontal bar moves through the seven rows of the first 5 x 7 character position. One and only one bar must be visible at a time. Movement will continue until any key is pressed.

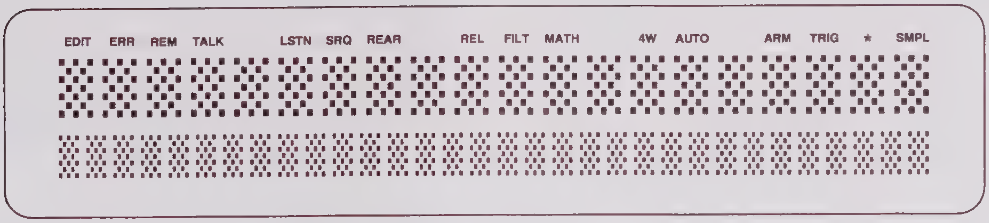


Figure 7-1
First pattern for display test

Pattern screen 4

A vertical bar moves through the five columns of the first 5 x 7 character position. One and only one bar must be visible at a time. Movement will continue until any key is pressed.

Pattern screen 5

All 35 dots of each 5 x 7 character block will turn on one character at a time. The upper row blocks include a number and (except for positions 5, 9, 13, and 16) an annunciator. Verify that one and only one block illuminates fully for each character position.

The first test pattern automatically appears when the display test commences. Press any key except EXIT to move to each successive pattern.

6. Verify all five patterns, then press EXIT to return to the TEST MENU.

7.6.7 Display test — char set

This test is used to display the ASCII character set.

1. Press the MENU key.
2. Select the TEST option and press ENTER.
3. Under the SELF TEST MENU, select the DISPLAY TESTS option.
4. Under DISPLAY TESTS, select CHAR-SET and press ENTER to display the ASCII charatcer set.
5. Press any key (except EXIT) to scroll through the character set.
6. When finished, use the EXIT key to back out of the menu structure.

7.7 Test descriptions and notes

The following information provides additional details for interpreting any error messages which may result during the Built-In-Tests. These notes are intended to help you isolate faults to the board level, rather than the component level.

7.7.1 Initial power-up test

Upon power-up, the Model 7001 writes test patterns to all volatile memory locations and checks that they read back properly. It then reads all ROM locations and verifies that a calculated checksum matches a checksum stored in ROM. If either of these tests fail, the digital board processor will continue to loop on these tests. If any of these tests fail, the display will indicate "No Comm Link" after the Model 7001 has been on for several seconds. This message indicates that the digital board has not communicated with the display board within the time-out interval.

After memory tests, the Model 7001 checks configuration data stored in non-volatile memory, configures the instrument according to power-up setups, and displays startup information. Configuration data is stored such that the Model 7001 may determine if it is valid. When a Model 7001 has power applied with uninitialized memory, it may briefly display a "configuration error" message.

7.7.2 Non-volatile memory tests

The Model 7001 uses two kinds of non-volatile memory, a 24C16 EEPROM (Electrically Erasable Programmable Read-Only Memory) and battery backed RAM. The EEPROM stores the IEEE-488 address, power-on setup memories and other mainframe configuration items. The battery backed RAM stores the scan list, forbidden channels, and relay card setup memories.

On initial power-up (or after replacing the battery or memory parts) the Model 7001 may indicate a configuration error. Such messages should not occur after programming setups.

The non-volatile memory test in this procedure stores a CARD TYPE in the EEPROM and a SCAN LIST in the battery backed RAM. Correct storage of these items after a few power line cycles provides a confidence test that the non-volatile memory is functioning properly.

NOTE

This test instructed you to set the CARD TYPE to "9990". The CARD TYPE setting will be changed if a Model 701X card is inserted in a card slot, and may result in an error message. The test must be performed with both card slots empty.

7.7.3 Built-in-tests

The following provides further details on the Built-In-Tests. If these tests detect a fault, they will report the following message at the conclusion of the test:

```
All tests complete *
Press ENTER to review or EXIT
```

To review the error, press ENTER. The display will show the test which failed. For further information on the failure, press INFO. Refer to the appropriate test numbers below for further explanations. The following discussions also suggest the most likely board failure for each type of error. You may also find it helpful to refer to the schematic diagrams.

Test 100 (EPROM)

Failure of Test 100 suggests a digital board error.

All ROM bytes (except for the checksum bytes) are read, a checksum is calculated and compared to the stored checksum. A fault of this test indicates that one or more ROM locations cannot be read properly. Check U113 and associated logic.

Test 101 (RAM)

Failure of Test 101 suggests a digital board error.

This is an abbreviated version of power-on RAM testing. Memory locations are written and read back. It is highly unlikely that this test will ever fail --- a unit with faulty RAM will probably fail the power-on memory test or lock up intermittently. Check U110, U111, and associated logic.

Test 102 (EEPROM)

Failure of Test 102 suggests a digital board error.

An attempt is made to read a byte of information from the 24C16 configuration EEPROM (U106) and an acknowledge signal is verified. A fault in this test indicates a problem with the 24C16 component or associated signals. The test does not verify the validity of configuration information stored in the EEPROM. Check U106.

Test 103 (Digital I/O)

NOTE

With some firmware revisions, the digital output tests (103.1 through 103.4) will not pass if the built-in test resistors are not present. (See paragraph 4.9.1.)

Failure of Test 103 suggests a micro DIN board error.

Digital I/O on the Model 7001 consists of four open-collector outputs, and one TTL-level input. Outputs originate from the 68302 microprocessor PA4-PA7 (U107). PA4 drives OUT1, PA5 drives OUT2, etc. These signals are buffered by a 2596 open collector driver (U601 on the micro DIN board).

Digital input is buffered by protection circuitry (CR600, CR609, R614, R615) and read by the 68302 at PB8.

Tests 103.1-103.2 — Digital output bits 1-4

Failure of Tests 103.1-103.2 suggests a micro DIN board error.

These tests make use of the fact that the 68302 Port A registers are bidirectional even though in normal use they are programmed as outputs only.

Diodes and resistors are connected around the 2596 so that OUT 1 feeds back to PA5, 2 feeds back to PA6, 3 to PA7, and 4 to PA4. (Note that signal numbers are scrambled at the 2596 open collector driver. The numbers in the above description refer to the digital output signal numbers, not to the numbers on the 2596.)

During Test 103.1, PA4 and PA6 are programmed as outputs, PA5 and PA7 are programmed as inputs. As PA4 (OUT1) is toggled high and low the signal is verified at PA5.

During Test 103.2, PA5 and PA7 are programmed as outputs, PA4 and PA6 are programmed as inputs. As PA5 (OUT2) is toggled high and low the signal is verified at PA6.

Tests 103.3-103.4 — OUT3 and OUT4 (test similar to 103.1-103.2).

Success of these tests assures the basic functionality of PA4-7, the 2596 and associated components. A failure may be caused by shorted or defective components or by open or shorted PC board traces.

Tests 103.5 — Digital Input

Failure of Test 103.5 suggests a micro DIN board or digital board error.

This test verifies that the digital input signal is pulled high at PB8 of the microprocessor (U107). Success of this test does not guarantee functionality. A failure may be caused by a defective component or a short circuit.

Test 104 (IEEE-488 Test)

Failure of Test 104 suggests a digital board error.

The IEEE-488 interface in the Model 7001 consists of the 9914 GPIB chip (U104), and the 75160 (U101) and 75161 (U100) bus drivers. The 75160 buffers DIO1-8 data lines, the 75161 buffers the bus handshake lines and other control signals. The circuitry to test these parts is contained in the 5064 ASIC (U103).

Test 104.1 — Handshake Test

Failure of Test 104.1 suggests a digital board error.

Circuitry in the 5064 is set up to simulate an IEEE-488 handshake. Bytes are written to the 9914 Data Out register and the interrupt status register is checked to verify that a Byte-Out handshake is completed.

These tests verify the basic functionality of the 9914, 75161, and the handshake portion of the ASIC (Signals BNRFD, BNDAC, and BDAV). Failures may indicate that a part is defective, or that the PC board is faulty. Check U100, U103, U104.

Test 104.2 — IEEE-Data

Failure of Test 104.2 suggests a digital board error.

Bytes are written to the 9914 Data Out register to drive and release bus line DIO1. The state of this signal is verified at the 68302 through PB0 (BITB1).

These tests verify the basic functionality of the 9914 and 75160. Failures may indicate that a part is defective or that the PC board is faulty. Check U101 and U104.

Test 105 — Trigger tests

Failure of Test 105 suggests a micro DIN board or digital board error.

Triggers in the Model 7001 are controlled by circuitry in the 5064 ASIC (U103). This part has seven trigger outputs (STO1-STO7) and eight trigger inputs (STI1-STI8).

The system trigger bus is controlled by STI1-STI6 and STO1-STO6.

STO7 is connected to the CHANNEL READY BNC connector. STI7 is connected to the EXTERNAL TRIGGER BNC connector.

STI8 is connected to the Group Execute Trigger signal (GET) of the 9914 IEEE-488 bus controller (U104).

Tests 105.1-105.6 — System Trigger Bus

Failure of Tests 105.1-105.6 suggests a micro DIN board or digital board error.

System trigger inputs are normally pulled up to +5V through protection diodes and 1kΩ resistors (CR102-107, R110-115). The Model 7001 may generate a trigger on any of the six trigger bus inputs by turning on a FET (Q100-105) controlled by the associated system trigger output pin (STO) of the ASIC.

In Test 105.1, STI1 is set up as the trigger input. The trigger 1 FET is then turned on and off through STO1, and it is verified that this trips the trigger circuitry in the ASIC. This test is then repeated for triggers 2-6 in tests 105.2 - 105.6.

Success indicates proper operation of the trigger bus. A fault may indicate a defective ASIC, FET, diode, resistor, or open-circuit board trace.

Test 105.7 — External Trigger/Channel Ready

Failure of Test 105.7 suggests a DIN or digital board error.

This test is similar to System Trigger Tests 105.1-105.6 except that there is no internal connection between EXTERNAL TRIGGER and CHANNEL READY. Consequently, the meaning of a fault is reversed from that of Tests 105.1-105.6, i.e., a fault is registered if a trigger does occur. This would indicate that a short exists between EXTERNAL TRIGGER and CHANNEL READY. This fact may be used to test the external BNC connectors. By shorting CHANNEL READY to EXTERNAL TRIGGER with a BNC cable, Test 105.7 should fail. If it does not, the signal path is faulty.

Test 105.8 — Group Execute Trigger (GET)

Failure of Test 105.8 suggests a digital board error.

Trigger 8 (STI8) is set up as input. The 9914 is then programmed to generate a GET signal. A failure may indicate a problem with the ASIC or with the 9914.

Tests 105.11-105.18 — Trigger Shorts tests

Failure of Tests 105.11-105.18 suggests a DIN board error.

In Test 105.11, STI1 is programmed as the trigger input. Each of the other triggers (STI2-STI7 and GET) are programmed to toggle in turn. If a trigger is detected at STI1, a short is indicated and the test fails. The test is repeated for STI2-STI8 in Tests 105.12-105.18.

Ordinarily, built-in-tests should be run with no external connections, however, the Trigger Shorts tests may be used to verify proper operation at the external TRIGGER LINK connectors (J1008, J1009). For example, by shorting pins 1 and 2, and selecting BIT 105, faults 105.11 and 105.12 should occur indicating that a short was detected between system trigger 1 and system trigger 2.

7.8 Troubleshooting

The following information is designed to help you troubleshoot the Model 7001 if a problem develops which resists diagnosis by the built-in tests. The BIT does not test to a 100% confidence level, but will detect and identify a majority of problems.

WARNING

Troubleshooting procedures may require you to apply power and operate the Model 7001 with the protective cover removed, thus exposing you to lethal voltages. To avoid risk of personal injury, refer any such procedures and testing to qualified personnel.

7.8.1 Digital board

The digital board contains most of the logic in the Model 7001, and is tested extensively by the BIT. If the BIT runs, the digital board (or at minimum, the microprocessor, RAM, EPROM, and EEPROM) is functional.

Raw power supply voltages can be measured at the point where they are cabled to the digital board from the power supply. Regulators on the digital board reduce the power supply +6VDC level to +5VDC. This voltage can be measured on regulators U118 and U119 and test points TP1000 and TP1003. The digital board also produces +60VDC used to power the fluorescent display. If this voltage is not present, the digital board is faulty. The lithium battery should measure 3-3.25VDC between the case (+) terminal and chassis ground.

CAUTION

Do not operate the Model 7001 with the digital board shield removed for an extended period of time, because the shield acts as a heat sink for one of the +5V regulators.

Most connections between the digital board and other boards are made through mass termination connectors, so there is a minimal chance of problems due to broken wires.

Symptom — Diagnostics do not run:

- Suspect a faulty digital board, display board, or power supply.

Symptom — A "No Comm Link" error indicates that the digital and display boards are not communicating. If this error occurs, check:

- Defective battery.
- Bad cable between digital board and display board.
- Defective digital board.
- Defective display board.

7.8.2 Display board

The display test verifies individual characters and annunciators on the display board. If the instrument powers up and executes this test, the display board and digital board logic are most likely operating properly. Problems with individual characters or annunciators should be easily identified. If the display is dead, check the condition of the ribbon cable connecting the digital and display boards. Serial communication and power for the display board (including 60VDC), are transmitted over this cable.

Symptom — No display:

- Defective power supply board. Check voltages.
- Blown fuse (power supply board). Check fuse.
- Loose power cable from power supply to digital board.
- Loose cable from AC receptacle to BNC board.
- Loose power feed from BNC board to power supply board.
- Loose ribbon cable from digital board to display board.
- Defective power switch (BNC board).
- Defective display board.
- Defective 60V supply (located on digital board).

Symptom — Front panel buttons not working as expected:

- Check the display board (run BIT)
- Check for broken or damaged contacts on keyboard button membranes.

Symptom — Display tests run but show incorrect characters:

- Change display board.

7.8.3 Power supply

The Model 7001 power supply will resist problems affecting conventional power supplies. The power supply automatically adjusts to a broad range of mains voltage (90-260VAC) and frequencies (47-440Hz), so the fuse should not fail because of incorrect mains voltage setting.

If the power supply fails, the instrument will be inoperative. Power supply input and output voltages may be checked at the connectors at each end of the board. Table 7-1 lists the ouptut voltages that shoud be checked.

Symptom — Repeated blowing of fuses indicates a faulty power supply or other boards:

- Disconnect the various wiring harnesses or remove boards and check for short circuits.

7.8.4 Micro DIN board

- The micro DIN board contains several ICs and discrete components for interfacing and protection. Failures are unlikely unless caused by external overloads. The BIT will test the micro DIN board to some degree.

Symptom — Improper communication with external equipment via micro DIN or BNC connectors:

- Check for broken or bent connector pins or external wiring.
- Check for defective BNC or micro DIN board.

7.8.5 Backplane board

The backplane board interfaces plug-in relay cards to the digital board. If communication through the backplane board is faulty, check the cards and the condition of the card edge connectors on the backplane board.

Symptom — Incorrect identification of relay cards plugged into backplane:

- Move the affected relay card into the other backplane slot. If it is correctly identified, suspect the backplane board. If not, suspect the relay card.

Symptom — Test circuit configurations not functioning properly:

- Defective or improperly seated relay cards.
- Defective backplane board.

7.8.6 BNC board

The BNC board contains only passive components. Mechanical components include the power switch and BNC connectors. The only signal cable from the BNC board carries BNC I/O to the micro DIN board. Failures are unlikely.

Table 7-1
Power supply checks

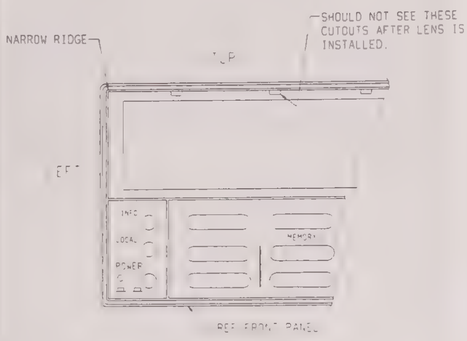
Test point	Output voltage	Tolerance	Rated load	Ripple/noise	
J102-1	+14.6VDC	±5%	1.67A	100mV	Referenced to J102-2
J102-4	+6VDC	±3%	2.5A	50mV	Referenced to J102-3, adjustable

Notes:
1. Tolerance is measured with output at 60% rated load.
2. Ripple/noise is measured by using a 12-inch twisted wire terminated with a 47μF capacitor.

NO. 7001-040

LTR	ECA NO	REVISION	EN	DATE
B9	16802	7001-11001 WAS 7001-1100	ST	[illegible]
B10	16924	7001-11002 WAS 7001-11001	[illegible]	[illegible]
B	[illegible]	704-324D Was 704-324C,2001-371A Was 2001 335D	ST	[illegible]
B 2	[illegible]	704-303C WAS 704 303B		1-97

DETAIL A - WINDOW LENS TO FRONT PANEL


NARROW RIDGE
TOP
SHOULD NOT SEE THESE CUTOUTS AFTER LENS IS INSTALLED.
LEFT
INFO
LOCAL
POWER
MEMORY
REF FRONT PANEL

RECOMMENDED PROCESS

PLACE THE LEFT SIDE OF THE LENS AGAINST THE LEFT NARROW RIDGE FIRST ON THE PANEL.

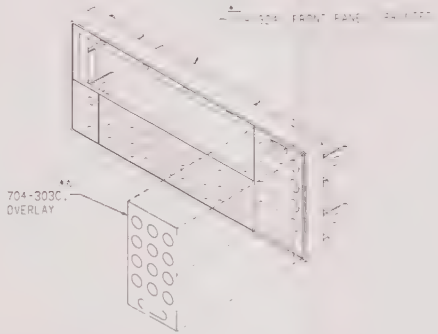
THEN PLACE THE TOP OF THE LENS AGAINST THE TOP NARROW RIDGE.

PRESS THE REST OF THE LENS INTO PLACE.

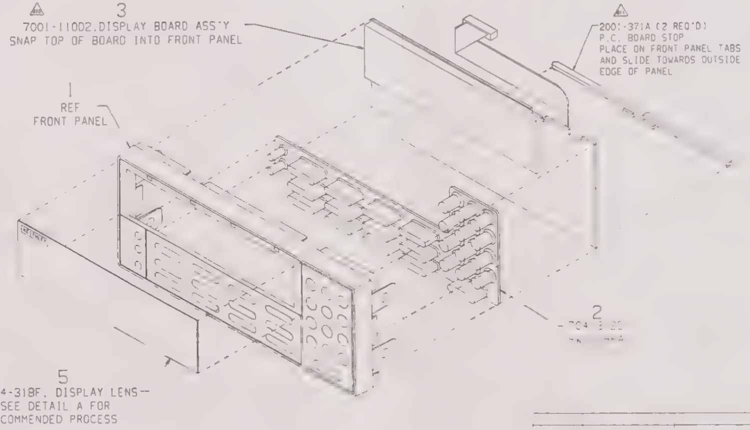
DO NOT REMOVE THE GREEN MASK FROM THE LENS.

CAUTION: THE LENS SHOULD NOT BE PLACED ON THE TOP OF THE NARROW RIDGE.

STEP 1


1 704-324 FRONT PANEL
704-303C OVERLAY

STEP 2


3
7001-11002 DISPLAY BOARD ASS'Y SNAP TOP OF BOARD INTO FRONT PANEL
2001-371A (2 REQ'D) P.C. BOARD STOP PLACE ON FRONT PANEL TABS AND SLIDE TOWARDS OUTSIDE EDGE OF PANEL
1 REF FRONT PANEL
2 704-312D SWITCHPAD
5 704-318F. DISPLAY LENS SEE DETAIL A FOR RECOMMENDED PROCESS

PART NO.	QTY	DESCRIPTION
704-324D	1	FRONT PANEL, PRINTED
704-312D	1	SWITCHPAD
704-318F	1	DISPLAY LENS
704-303C	1	OVERLAY
7001-11002	1	DISPLAY BOARD ASS'Y
2001-371A	2	P.C. BD STOP

MODEL	NEXT ASSEMBLY	NEXT PROCESS STEP	QTY
7001	7001-054	FINAL CHASSIS ASS'Y	

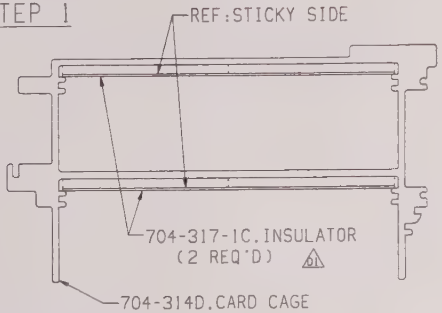
USED ON

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 9-25-91	SCALE 1/2	TITLE FRONT PANEL ASS'Y OP9
KEITHLEY Keithley Instruments Inc Cleveland, Ohio 44139	XX - ±.015 ANG - ±1°	DRN KAS	ENG APPR	
	XXX - ± 005 FRAC - ±1/64	MATERIAL	C	NO 7001-040
	SURFACE MAX 63	FINISH		

NO. 7001-050

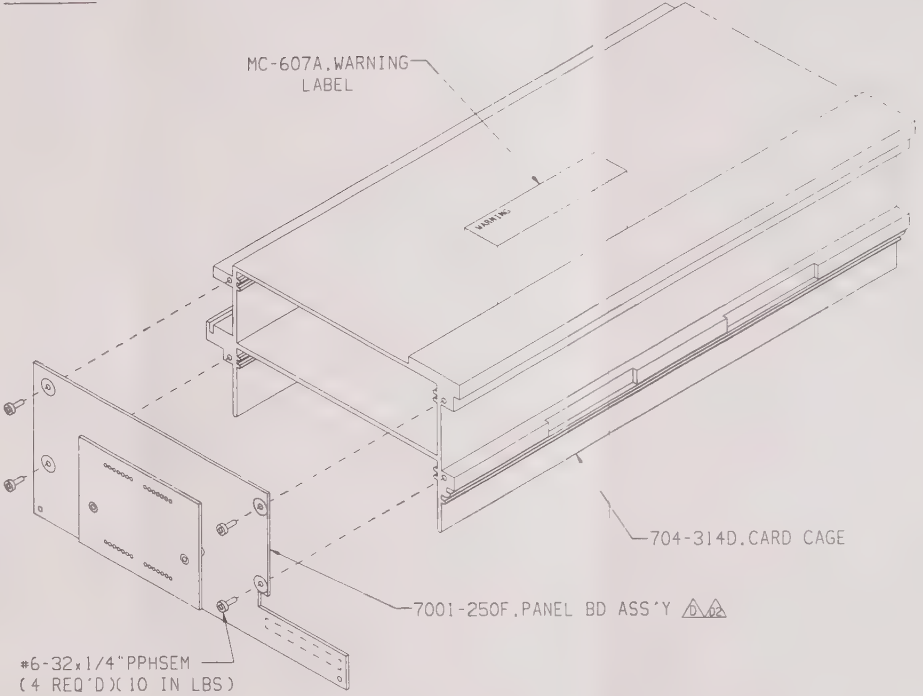
LTR	ECA NO.	REVISION	ENG	DATE
D2	20393	700.-250F Wos 7001-250E	St	2/11/9?

STEP 1


REF:STICKY SIDE
704-317-1C.INSULATOR
(2 REQ'D) D1
704-314D.CARD CAGE

RECOMMENDED PROCESS:
- REMOVE BACKING FROM INSULATOR.
- POSITION INSULATOR ON TOP OF RAILS (STICKY SIDE AWAY FROM RAILS).
- SLIDE INTO CARD CAGE KEEPING INSULATOR AGAINST RAILS.
- WHEN COMPLETELY INSTALLED, PRESS TOWARD SURFACE OF CARD CAGE.
- INSTALL OTHER INSULATOR IN THE SAME WAY.
- TURN UNIT OVER AND PRESS ENTIRE LENGTH OF INSULATORS TO CARD CAGE.
- TURN ON ION PUMP TO BLOW THRU CARD CAGE TO DISSIPATE STATIC CHARGE ON INSULATORS.

STEP 2


MC-607A.WARNING LABEL
WARNING
704-314D.CARD CAGE
7001-250F.PANEL BD ASS'Y D D2
#6-32x1/4"PPHSEM
(4 REQ'D)(10 IN LBS)

PLACE T-7569 BOARD INTO CARD CAGE FOR ALIGNMENT OF BACKPLANE BOARD.

PART NO.	QTY	DESCRIPTION	
704-314D	1	CARD CAGE	
704-317-1C	2	INSULATOR	D1
7001-250F	1	PANEL BOARD ASS'Y	D D2
MC-607A	1	WARNING LABEL	
#6-32x1/4"PPHSEM	4	PHIL PAN HD SEMS SCREW	

7001	7001-051	CHASSIS ASS'Y	1
MODEL	NEXT ASSEMBLY	NEXT PROCESS STEP	QTY
USED ON			

DO NOT SCALE THIS DRAWING

KEITHLEY Keithley Instruments Inc.
Cleveland, Ohio 44139

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX = ±.015 ANG = ±1°
XXX = ±.005 FRAC = ±1/64
SURFACE MAX 63

DATE 9/26/91
SCALE 1/2
DRN kos
ENG APPR MTF
MATERIAL
FINISH

TITLE CARD CAGE ASS'Y OP9

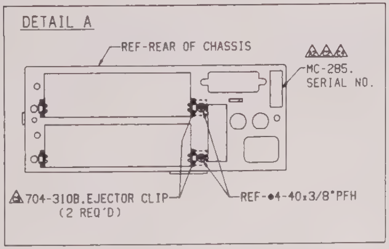
B

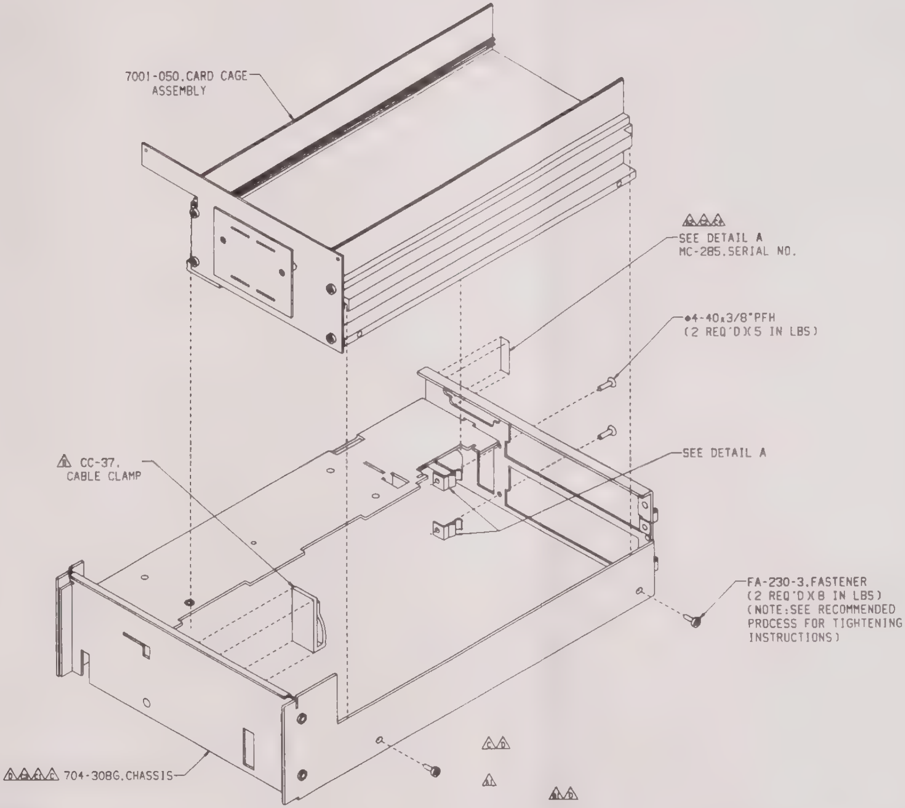
NO. 7001 050

ORIGINAL IF RED

NO. 7001-051

LTR	ECA NO.	REVISION	ENG	DATE
D	15684	DELETED (4) 486-312A. 704-308G WAS 704 308F	SJ	6/16/93


DETAIL A
REF-REAR OF CHASSIS
MC-285.
SERIAL NO.
704-310B.EJECTOR CLIP
(2 REQ'D)
REF-●4-40x3/8"PFH


7001-050.CARD CAGE
ASSEMBLY
SEE DETAIL A
MC-285.SERIAL NO.
●4-40x3/8"PFH
(2 REQ'D)(5 IN LBS)
SEE DETAIL A
CC-37.
CABLE CLAMP
FA-230-3.FASTENER
(2 REQ'D)(8 IN LBS)
(NOTE:SEE RECOMMENDED
PROCESS FOR TIGHTENING
INSTRUCTIONS)
704-308G.CHASSIS

RECOMMENDED PROCESS:
TO INSERT CARD CAGE. TILT THE CENTER SIDE THRU THE CHASSIS FIRST.
THEN ALIGN THE 3 RECTANGULAR LOCKING TABS TO THE SLOTS ON THE CHASSIS.
SLIDE CARD CAGE THRU SLOTS.
LIFT UP ON CHASSIS TO ENABLE CARD CAGE TO DROP FULLY INTO PLACE.
PUSH CARD CAGE TOWARDS REAR OF CHASSIS.
INSTALL FASTENER TO THE CARD CAGE. DO NOT TIGHTEN.
SLIDE EJECTOR CLIPS BETWEEN CARD CAGE AND REAR OF CHASSIS.
SECURE WITH SCREW.
TIGHTEN FASTENER.
THEN INSTALL REST OF COMPONENTS.

PART NO.	QTY	DESCRIPTION
7001-050	1	CARD CAGE ASS'Y
704-308G	1	CHASSIS
CC-37	1	CABLE CLAMP
FA-230-3	2	FASTENER, ●6 SCREW
704-310B	2	EJECTOR CLIP
●4-40x3/8"PFH	2	PHIL FLAT HD SCREW
MC-285	1	SERIAL NO.

MODEL	NEXT ASSEMBLY	NEXT PROCESS STEP	QTY
7001	7001-052C	DIGITAL BD/CHASSIS ASS'Y	1

USED ON

DO NOT SCALE THIS DRAWING

KEITHLEY Keithley Instruments Inc. Cleveland, Ohio 44139

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX = ±.015 ANG = ±1°
XXX = ±.005 FRAC = ±1/64
SURFACE MAX 63

DATE 9-25-91
SCALE 1:2
DRN KAS
ENG APPR MJF
MATERIAL
FINISH

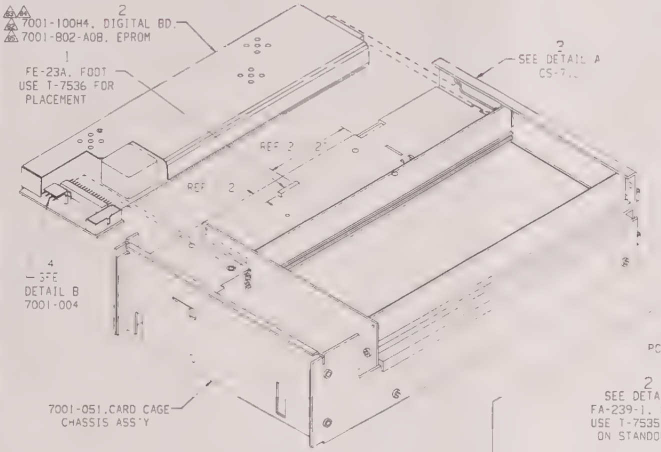
TITLE CARD CAGE/CHASSIS ASSEMBLY OP9

C NO. 7001-051

NO. C7001-052

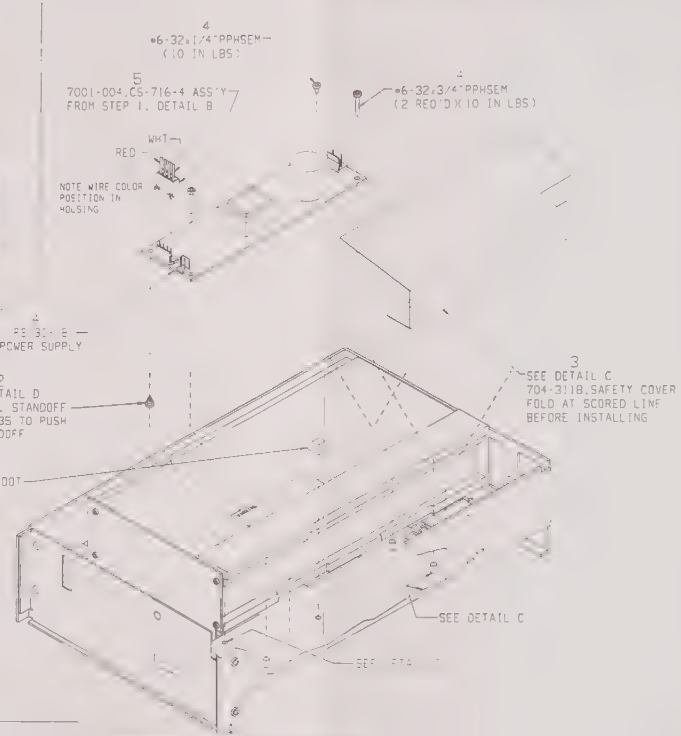
LTR	ECA NO.	REVISION		
B2	16424	7001-802A05 WAS 700 -802A04		
B3	17452	7001-100H2 WAS 700 -.00H1		
B4	[illegible]	7001-100H3 WAS 7001-100H2		
B5	21201	7001-100H4 WAS 700 -100H3		

STEP 1



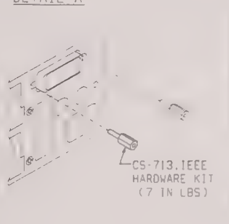
2
B3 B4 7001-100H4, DIGITAL BD.
B5 7001-802-A08, EPROM
1
FE-23A, FOOT
USE T-7536 FOR
PLACEMENT
3
SEE DETAIL A
CS-7..
REF 2
REF 2
4
SEE
DETAIL B
7001-004
7001-051,CARD CAGE
CHASSIS ASS'Y

STEP 2



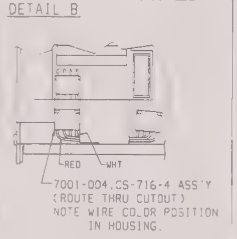
4
*6-32x1/4"PPHSEM
(10 IN LBS)
5
7001-004,CS-716-4 ASS'Y
FROM STEP 1, DETAIL B
4
*6-32x3/4"PPHSEM
(2 REQ'D X 10 IN LBS)
WHT
RED
NOTE WIRE COLOR
POSITION IN
HOUSING
4
PS-30-1B
POWER SUPPLY
2
SEE DETAIL D
FA-239-1, STANDOFF
USE T-7535 TO PUSH
ON STANDOFF
1
FE-12, FOOT
3
SEE DETAIL C
704-311B,SAFETY COVER
FOLD AT SCORED LINE
BEFORE INSTALLING
SEE DETAIL C
SEE DETA

DETAIL A



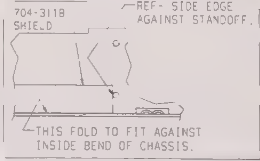
CS-713,IEEE
HARDWARE KIT
(7 IN LBS)

DETAIL B



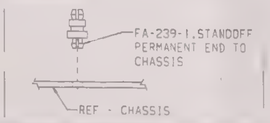
RED
WHT
7001-004,CS-716-4 ASS'Y
(ROUTE THRU CUTOUT)
NOTE WIRE COLOR POSITION
IN HOUSING.

DETAIL C



704-311B
SHIELD
REF- SIDE EDGE
AGAINST STANDOFF.
THIS FOLD TO FIT AGAINST
INSIDE BEND OF CHASSIS.

DETAIL D



FA-239-1,STANDOFF
PERMANENT END TO
CHASSIS
REF - CHASSIS

PART NO.	QTY	DESCRIPTION
7001-051	1	CARD CAGE ASS'Y
7001-100H4	1	DIGITAL BOARD (7001-802A08-EPROM) B2 B3 B4 B5
704-311B		SAFETY COVER
FA-239		STANDOFF
FE 23A		FOOT
FE .2		FOOT
CS-713	1	IEEE HARDWARE KIT
PS-30-1B	1	POWER SUPPLY
7001-004	1	WIRE CRIMP
*6-32x3/4"PPHSEM	2	PHIL PAN HD SEMS SCREW
*6-32x1/4"PPHSEM	1	PHIL PAN HD SEMS SCREW

7001	7001-053C	CHASSIS ASS'Y	1
MODEL	NEXT ASSEMBLY	NEXT PROCESS STEP	QTY

DO NOT SCALE THIS DRAWING

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX = ±.015 ANG = ±1°
XXX = ±.005 FRAC = ±1/64
SURFACE MAX 63

KEITHLEY Keithley Instruments Inc Cleveland Ohio 44139

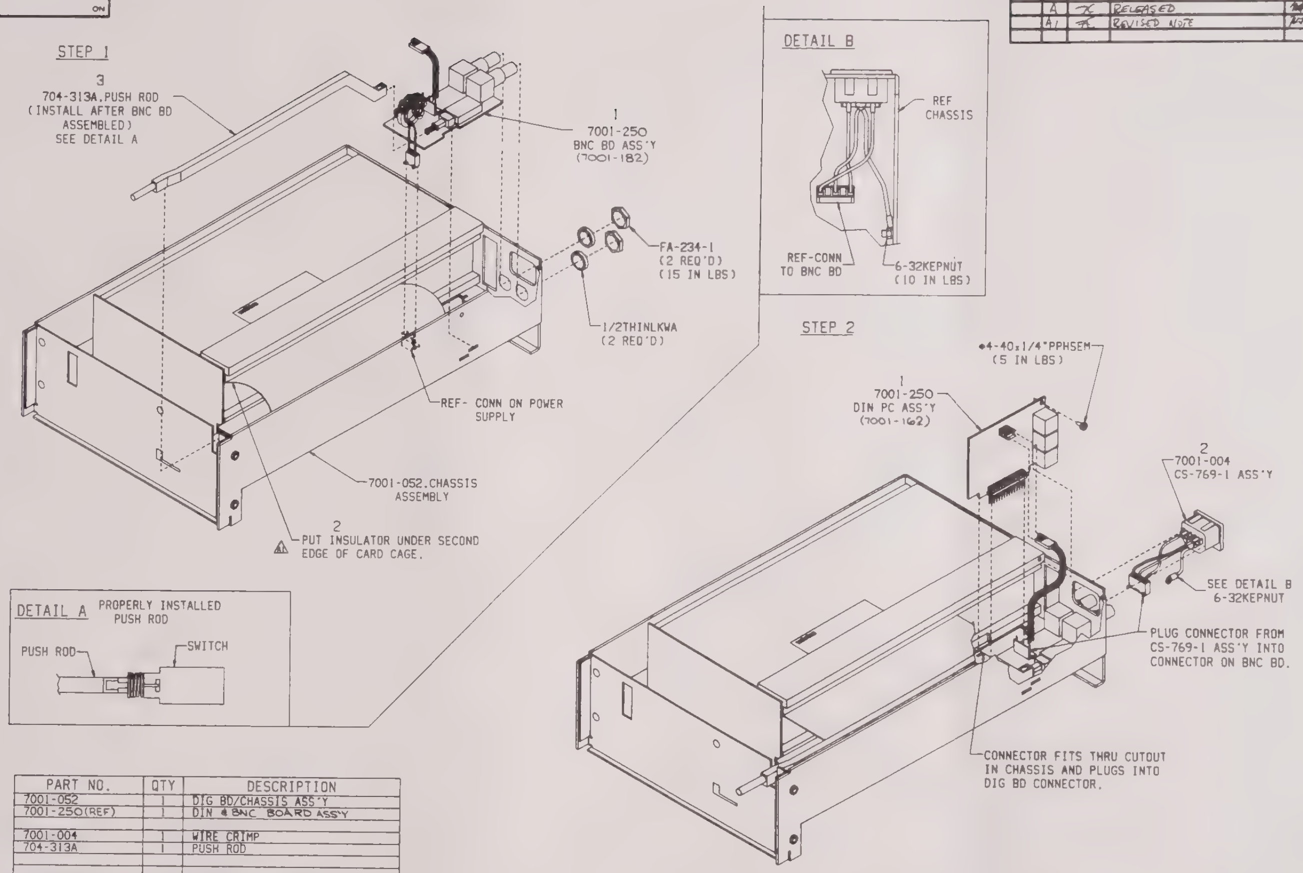
DATE 4 4 9 SCALE
DRN KAS
ENG APPR MJF
MATERIAL
FINISH

DIGITAL BD/CHASSIS
ASSEMBLY OP9

C NO 7001-052

850-100L
ON

ZONE	LTR	ECO NO	REVISION	ENG	DATE
	A		RELEASED		1/2/81
	A1		REVISED NOTE		


STEP 1
3
704-313A.PUSH ROD
(INSTALL AFTER BNC BD
ASSEMBLED)
SEE DETAIL A
1
7001-250
BNC BD ASS'Y
(7001-182)
FA-234-1
(2 REQ'D)
(15 IN LBS)
1/2THINLKWA
(2 REQ'D)
REF- CONN ON POWER
SUPPLY
7001-052.CHASSIS
ASSEMBLY
2
PUT INSULATOR UNDER SECOND
EDGE OF CARD CAGE.
DETAIL A
PROPERLY INSTALLED
PUSH ROD
PUSH ROD
SWITCH
DETAIL B
REF
CHASSIS
REF-CONN
TO BNC BD
6-32KEPNUT
(10 IN LBS)
STEP 2
●4-40x1/4"PPHSEM
(5 IN LBS)
1
7001-250
DIN PC ASS'Y
(7001-162)
2
7001-004
CS-769-1 ASS'Y
SEE DETAIL B
6-32KEPNUT
PLUG CONNECTOR FROM
CS-769-1 ASS'Y INTO
CONNECTOR ON BNC BD.
CONNECTOR FITS THRU CUTOUT
IN CHASSIS AND PLUGS INTO
DIG BD CONNECTOR.

PART NO.	QTY	DESCRIPTION
7001-052	1	DIG BD/CHASSIS ASS'Y
7001-250(REF)	1	DIN & BNC BOARD ASS'Y
7001-004	1	WIRE CRIMP
704-313A	1	PUSH ROD
FA-234-1	2	1/2-28 SMALL NUT
1/2THINLKWA	2	THIN LOCKWASHER
●4-40x1/4"PPHSEM	1	PHIL PAN HD SEMS SCREW
●6-32KEPNUT	1	KEPNUT

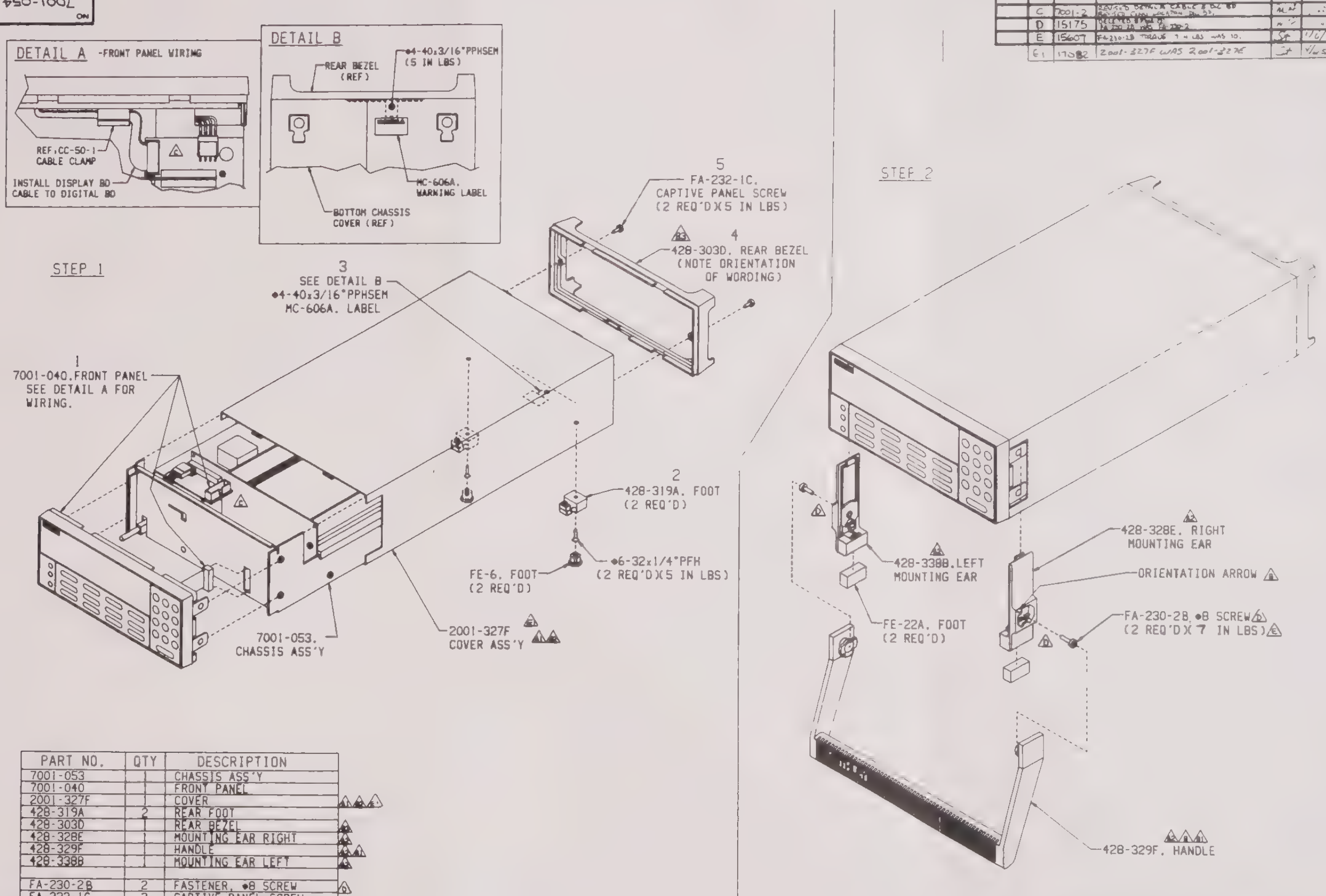
FINAL CHASSIS ASS'Y NEXT PROCESS STEP	7001	7001-054C	1
	MODEL	NEXT ASSEMBLY	QTY
	USED ON		

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE	SCALE 1/2	TITLE CHASSIS ASSEMBLY OP9
Keithley Instruments Inc. Cleveland, Ohio 44139	XX = ± .010 ANG = ±1°	DRN	ENG APPR. 7/1/81	
	XXX = ± .005 FRAC = ±1/64	MATERIAL		C
	SURFACE MAX 63	FINISH		NO 7001-053

BRUNING 58425 03

FORM 30153C REV 0

ZONE	LTR	ECO NO	REVISION	ENG	DATE
	C	7001-2	REVISED DETAIL A CABLE & DG BD REVISED CLAMP LOCATION [illegible]	[illegible]	
	D	15175	[illegible] FA-230-2B WAS FA-230-2	[illegible]	
	E	15607	FA-230-2B TORQUE 7 IN LBS WAS 10.	[illegible]	1/6/93
	E1	17082	2001-327F WAS 2001-327E	[illegible]	[illegible]



7001-054
DETAIL A -FRONT PANEL WIRING
REF, CC-50-1 CABLE CLAMP
INSTALL DISPLAY BD CABLE TO DIGITAL BD
DETAIL B
REAR BEZEL (REF)
#4-40x3/16"PPHSEM (5 IN LBS)
MC-606A. WARNING LABEL
BOTTOM CHASSIS COVER (REF)
STEP 1
5
FA-232-1C. CAPTIVE PANEL SCREW (2 REQ'D)(5 IN LBS)
4
428-303D. REAR BEZEL (NOTE ORIENTATION OF WORDING)
3
SEE DETAIL B
#4-40x3/16"PPHSEM
MC-606A. LABEL
1
7001-040. FRONT PANEL SEE DETAIL A FOR WIRING.
2
428-319A. FOOT (2 REQ'D)
#6-32x1/4"PFH (2 REQ'D)(5 IN LBS)
FE-6. FOOT (2 REQ'D)
7001-053. CHASSIS ASS'Y
2001-327F COVER ASS'Y
STEP 2
428-328E. RIGHT MOUNTING EAR
428-338B. LEFT MOUNTING EAR
ORIENTATION ARROW
FE-22A. FOOT (2 REQ'D)
FA-230-2B #8 SCREW (2 REQ'D)(7 IN LBS)
428-329F. HANDLE

PART NO.	QTY	DESCRIPTION
7001-053	1	CHASSIS ASS'Y
7001-040	1	FRONT PANEL
2001-327F	1	COVER
428-319A	2	REAR FOOT
428-303D	1	REAR BEZEL
428-328E	1	MOUNTING EAR RIGHT
428-329F	1	HANDLE
428-338B	1	MOUNTING EAR LEFT
FA-230-2B	2	FASTENER, #8 SCREW
FA-232-1C	2	CAPTIVE PANEL SCREW
FE-6	2	FOOT
FE-22A	2	FOOT
MC-606A	1	WARNING LABEL, GROUND
#4-40x3/16"PPHSEM	1	PHIL PAN HD SEMS SCREW
#6-32x1/4"PFH	2	PHIL FLAT HD SCREW

FINAL INSPECTION
TECH
NEXT PROCESS STEP

7001	7001-080B	1
7001	TECH	1
MODEL	NEXT ASSEMBLY	QTY
USED ON		

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE [illegible]	SCALE 1/2
Keithley Instruments Inc Cleveland Ohio 44139	XX = ± .015 ANG = ± 1°	DRN [illegible]	ENG APPR. [illegible]
	XXX = ± .005 FRAC = ± 1/64	MATERIAL —	
	SURFACE MAX 63	FINISH —	

TITLE FINAL CHASSIS ASS'Y OP9

C NO. 7001-054

BRUNING 58425-03

8

Replacable Parts

8.1 Introduction

This section contains information concerning replacement parts, schematic diagrams, component layouts, and procedures for obtaining factory service for the Model 7001.

8.2 Electrical components list

Electrical components for the Model 7001 can be obtained from Keithley. Component designations and locations can be checked using the schematic and component diagrams. The parts list, shown later in this section, specifies components alphabetically, in order of circuit designation.

NOTE

Most components within the Model 7001 are soldered in place using surface-mount assembly techniques. Replacement of such components requires special equipment and expertise. Refer repair of such boards to qualified personnel or the factory.

8.3 Mechanical parts

The part numbers for the various mechanical parts and assemblies of the Model 7001 are listed on the assembly drawings included at the end of Section 7.

8.4 Ordering information

Keithley Instruments, Inc. maintains a complete inventory of all normal replacement parts. To place an order, or to obtain information concerning replacement parts, contact your local Keithley representative, or the factory:

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, OH 44139
(440) 248-0400

When ordering parts, include the following information:

1. Instrument model number.
2. Instrument serial number.
3. Part description.
4. Circuit designation, including (if applicable) the numbers of the schematic and component layout diagrams where the component appears.
5. Keithley part number.

8.5 How to obtain factory service

If the instrument or associated accessories are to be returned to the factory for service, carefully pack them (preferably in the original carton), and include the following information:

1. Complete the service form found at the end of this manual and return it with the instrument.
2. Advise as to the warranty status of the instrument (see the inside front cover of this manual for warranty information).
3. Write the following on the shipping label: ATTENTION REPAIR DEPARTMENT.
4. Call the Instruments Division Repair Department at 1-800-552-1115 for a Return Material Authorization (RMA) number.

8.6 Document list

The schematic and component layout diagrams for the Model 7001 are located at the end of this section. Reference them through the following designations:

- Digital Board, Schematic Diagram 7001-106, and Component Layout 7001-100.
- Display Board, Schematic Diagram 7001-116, and Component Layout 7001-110.
- Micro DIN Board, Schematic Diagram 7001-166, and Component Layout 7001-160.
- Backplane Board, Schematic Diagram 7001-176, and Component Layout 7001-170.
- BNC Board, Schematic Diagram 7001-186, and Component Layout 7001-180.

Table 8-1

Digital Board, Parts List

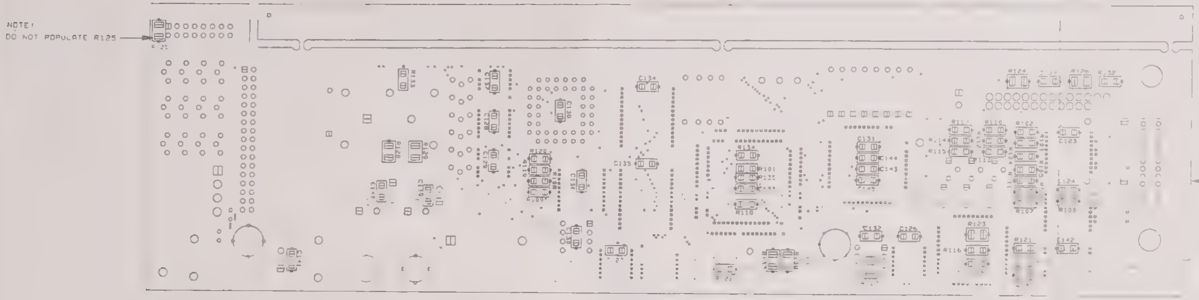
Circuit desig.	Description	Keithley part no.
	DIGITAL BOARD ASSEMBLY	7001-100
	DIGITAL SHIELD	704-323
	FOR U118 HEAT SINK	HS-33
	USE WITH U113 SOCKET, 44 PIN QUAD	SO-128-44
BT100	BATTERY, LITHIUM	BA-44
C100	CAP,22UF,-20+100%,25V,ALUM ELEC	C-314-22
C101,102	CAP,220UF,-20+100%,25V,ALUM ELEC	C-314-220
C103	CAP, 47UF,10%,16V,ALUM ELEC	C-321-47
C104-121	CAP,270PF,20%,100V,CERAMIC/FERRITE	C-386-270P
C122-130	CAP, .01uF, 20%, 50V, CERAMIC (1206)	C-418-.01
C131-145	CAP,.1UF, 20%,50V,CERAMIC(1206)	C-418-.1
C146	CAP, 10UF,20%, 25V, TANTALUM (D7243)	C-440-10
C147,148	CAP, 33PF, 10%, 100V, CERAMIC (1206)	C-451-33P
CR100-107	DIODE,SILICON,1N4148 (DO-35)	RF-28
CR108,109	DIODE,ARRAY,MMAD1103,(SOIC)	RF-80
E100	FERRITE BEAD	CT-8
J1002	CONN,RIGHT ANGLE,24PIN	CS-507
J1003	SOCKET, BOTTOM ENTRY	CS-771-28
J1005	FOR DISPLAY CABLE CONN, HEADER STRAIGHT SOLDER PIN	CS-368-16
J1006	CONNECTOR, HEADER	CS-715-4
L100,101	POWER FILTER CHOKE, 10UH,3A	CH-20-2
M104	BATTERY HOLDER	BH-34
P1004	CONNECTOR, DUAL ROW	CS-770-34
Q100-105	TRANS,N CHAN TMOS FET, 2N7000 (TO-92)	TG-195
R100-109	RES,10K,5%,125MW,METAL FILM(1206)	R-375-10K
R110-115	RES, 5.1K,5%, 125MW, METAL FILM (1206)	R-375-5.1K
R116-120	RES,4.7K,5%,125MW,METAL FILM(1206)	R-375-4.7K
R121	RES, 470,5%, 125MW, METAL FILM(1206)	R-375-470
R122	RES, 680K, 5%,125mW, METAL FILM (1206)	R-375-680K
R123,124	RES,100,5%,250MW,METAL FILM(1210)	R-376-100
R126,127,138	RES, 10K, 5%, 250MW, METAL FILM(1210)	R-376-10K
R128,129	RES, 4.7K, 5%, 250MW, METAL FILM(1210)	R-376-4.7K
R130,131	RES, 560, 5%, 250mW, METAL FILM (1210)	R-376-560
R132-135	RES, 2K, 1%, 125mW, METAL FILM (1206)	R-391-2K
R136	RES NET,4.7K,2%,1.875W(SOMIC)	TF-219-4.7K
R137	RES, 1.5K, 5%, 250MW, METAL FILM(1210)	R-376-1.5K
TP100-102	CONN,TEST POINT	CS-553

Table 8-1 (continued)
Digital Board, Parts List

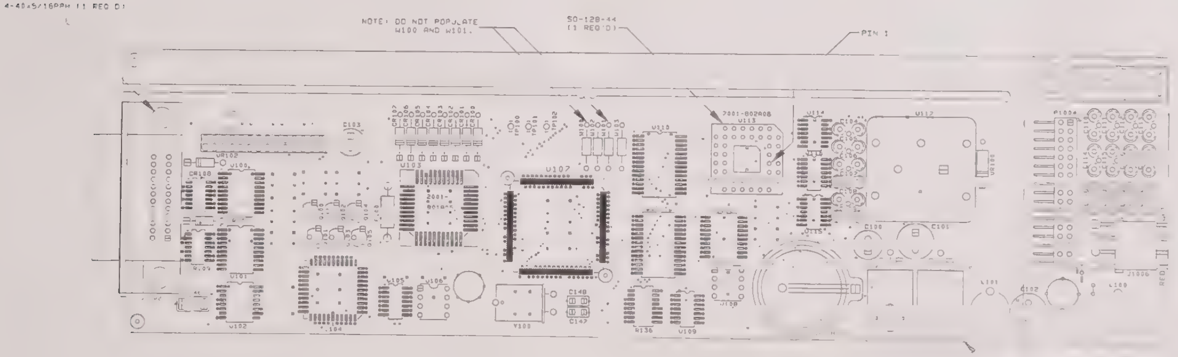
Circuit desig.	Description	Keithley part no.
U100	IC,OCTAL INTER BUS TRANS,75161(SOLIC)	IC-647
U101	IC,OCTAL INTERFACE BUS,75160(SOLIC)	IC-646
U102	IC, DUAL POWER-SUPPLY SUPER, TL7770-5	IC-805
U103	PROGRAM	7001-801A01
U104	IC, GPIB ADAPTER, 9914A (PLCC)	LSI-123
U105	IC, QUAD 2 IN NOR, 74HCT02 (SOIC)	IC-809
U106	IC, SERIAL E EPROM, X24C16(8-PIN DIP)	IC-736
U107	IC, 16-BIT MICRO, MC68302	LSI-106
U108	IC,NONVOLATILE CONTROLLER DS1210	IC-541
U109,115	IC, QUAD 2 INPUT OR, 74HCT32 (SOIC)	IC-808
U110,111	IC,32KX8 STAT CMOS RAM,D43256C(SOMETRIC)	LSI-93-100
U112	IC,OCT BFR/LINE DRIVE,74HCT244(SOLIC)	IC-651
U113	PROGRAM	7001-802A02
U114	IC, DUAL D F/F 74HCT74(SOIC)	IC-838
U116	IC, QUAD 2 IN AND, 74HCT08(SOIC)	IC-837
U117	MOD,DC-AC/DC, 5DV-5VAC/60DC,E705-E905VF	MO-30
U118,119	IC,+5V VOLTAGE REGULATOR,LM2940CT	IC-576
VR100	DIODE, ZENER 8.2V, 1N4101 (DO-7)	DZ-82
W102,103	JUMPER	J-15
Y100	CRYSTAL, 16MHZ	CR-30-16M

7001-100

LTR	ECO NO	REVISION	ENG	DATE
C	19,0304	RELEASED		
		REVISED		
	4774	REVISED		
	14862	ADDED DO NOT POPULATE		
F	14919	[illegible]		
F1	15626	ADDED TRIM LEAD NOTE		
G	15214	CHG C ARTWORK REV FROM F TO G	SZ	
G1	15557	ADDED 7001-802A04 TO U113	SZ	
H	15635	ARTWORK WAS REV [illegible] ADDED VR101 & VR102	RS	2-12-93
H1	16424	U113 WAS 7001-802A04	SZ	
H2	17452	[illegible]	SZ	5 9 95
H3	17052	REMOVED [illegible] SIDE 01		
H4	21201	7001-802A08 WAS 7001-802A07		


NOTE!
DO NOT POPULATE R125
R125
R124
R133
R134
C134
C135
C136
C131
C144
C143
C132
C126
C123
C124
C142
R101
R110
R111
R113
R114
R115
R116
R118
R121
R123
R100
R107
R128
R129

SOLDER SIDE (SIDE 01)


4-40x5/16PPH (1 REQ'D)
NOTE: DO NOT POPULATE
W100 AND W101.
SO-128-44
(3 REQ'D)
PIN 1
7001-802A08
U113
U114
U112
U110
U107
U103
U100
U101
U102
U104
U105
U106
U108
U109
U111
VR100
VR101
VR102
CR100
C100
C101
C102
C103
C104
C105
C106
C107
C108
C147
C148
L100
L101
P1004
J1006
J1008
Y100
R136

COMPONENT SIDE (SIDE 06)

NOTE: TRIM LEADS TO .060 MAX.

DO NOT SCALE THIS DRAWING

KEITHLEY
KEITHLEY INSTRUMENTS
CLEVELAND OHIO

MATERIAL

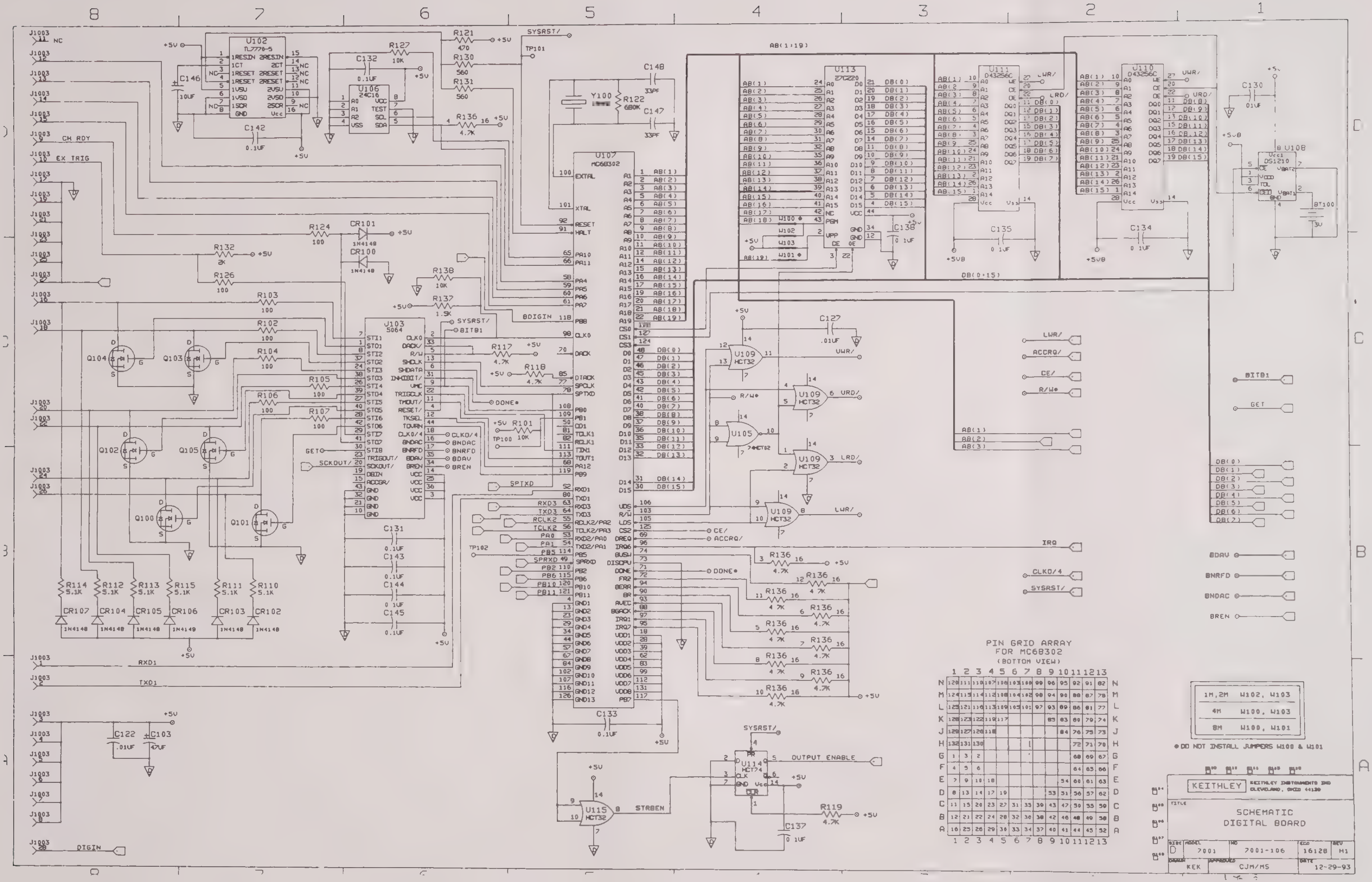
SURFACE

FINISH

DIGITAL BOARD

D

NO. 2001-100


8
7
6
5
4
3
2
1
D
C
B
A
J1003
NC
CH RDY
EX TRIG
RXD1
TXD1
DIGIN
+5V
U102
TL7770-5
1RESIN
2RESIN
1CT
2CT
1RESET
2RESET
1VSU
2VSU
1VSO
2VSO
1SCR
2SCR
GND
Vcc
C146
10UF
C142
0.1UF
C132
0.1UF
U106
24C16
A0
A1
A2
VSS
VCC
TEST
SCL
SDA
R127
10K
R121
470
R130
560
R131
560
R136
4.7K
SYSRST/
TP101
Y100
R122
680K
C148
33PF
C147
33PF
U107
MC68302
EXTAL
XTAL
RESET
HALT
R124
100
CR101
1N4148
CR100
1N4148
R132
2K
R126
100
R138
10K
R137
1.5K
BDIGIN
R103
100
R102
100
R104
100
R105
100
R106
100
R107
100
U103
5064
Q104
Q103
Q102
Q105
Q100
Q101
R117
4.7K
R118
4.7K
DONE
DACK
DTACK
SPCLK
SPTXD
R101
10K
TP100
GET
SCKOUT/
SPTXD
RXD3
TXD3
RCLK2
TCLK2
PA0
PA1
PB5
SPRXD
PB2
PB6
PB10
PB11
TP102
C131
0.1UF
C143
0.1UF
C144
0.1UF
C145
0.1UF
R114
5.1K
R112
5.1K
R113
5.1K
R115
5.1K
R111
5.1K
R110
5.1K
CR107
CR104
CR105
CR106
CR103
CR102
1N4148
CLKO/4
BNDAC
BNRFD
BDAV
BREN
BITB1
C122
.01UF
C103
47UF
C133
0.1UF
AB(1:19)
U113
27C220
W100
W102
W103
W101
C138
0.1UF
U111
D43256C
U110
D43256C
LWR/
LRD/
UWR/
URD/
C135
0.1UF
C134
0.1UF
+5VB
C130
0.1UF
U108
DS1210
BT100
3V
DB(0:15)
C127
.01UF
U109
HCT32
U105
74HCT02
R/W
CE/
ACCRQ/
IRQ
OUTPUT ENABLE
U114
HCT74
U115
HCT32
STRBEN
R119
4.7K
C137
0.1UF
DB(0)
DB(1)
DB(2)
DB(3)
DB(4)
DB(5)
DB(6)
DB(7)
AB(1)
AB(2)
AB(3)
BDAV
BNRFD
BNDAC
BREN

PIN GRID ARRAY
FOR MC68302
(BOTTOM VIEW)

	1	2	3	4	5	6	7	8	9	10	11	12	13	
N	120	111	110	107	106	103	100	99	96	95	92	91	82	N
M	124	115	114	112	108	104	102	98	94	90	88	87	78	M
L	125	121	116	113	109	105	101	97	93	89	86	81	77	L
K	128	123	122	119	117				85	83	80	79	74	K
J	129	127	126	118						84	76	75	73	J
H	132	131	130								72	71	70	H
G	1	3	2								68	69	67	G
F	4	5	6								64	65	66	F
E	7	9	10	18						54	60	61	63	E
D	8	13	14	17	19				53	51	56	57	62	D
C	11	15	20	23	27	31	35	39	43	47	50	55	59	C
B	12	21	22	24	28	32	36	38	42	46	48	49	58	B
A	16	25	26	29	30	33	34	37	40	41	44	45	52	A
	1	2	3	4	5	6	7	8	9	10	11	12	13	

1M,2M	W102, W103
4M	W100, W103
8M	W100, W101

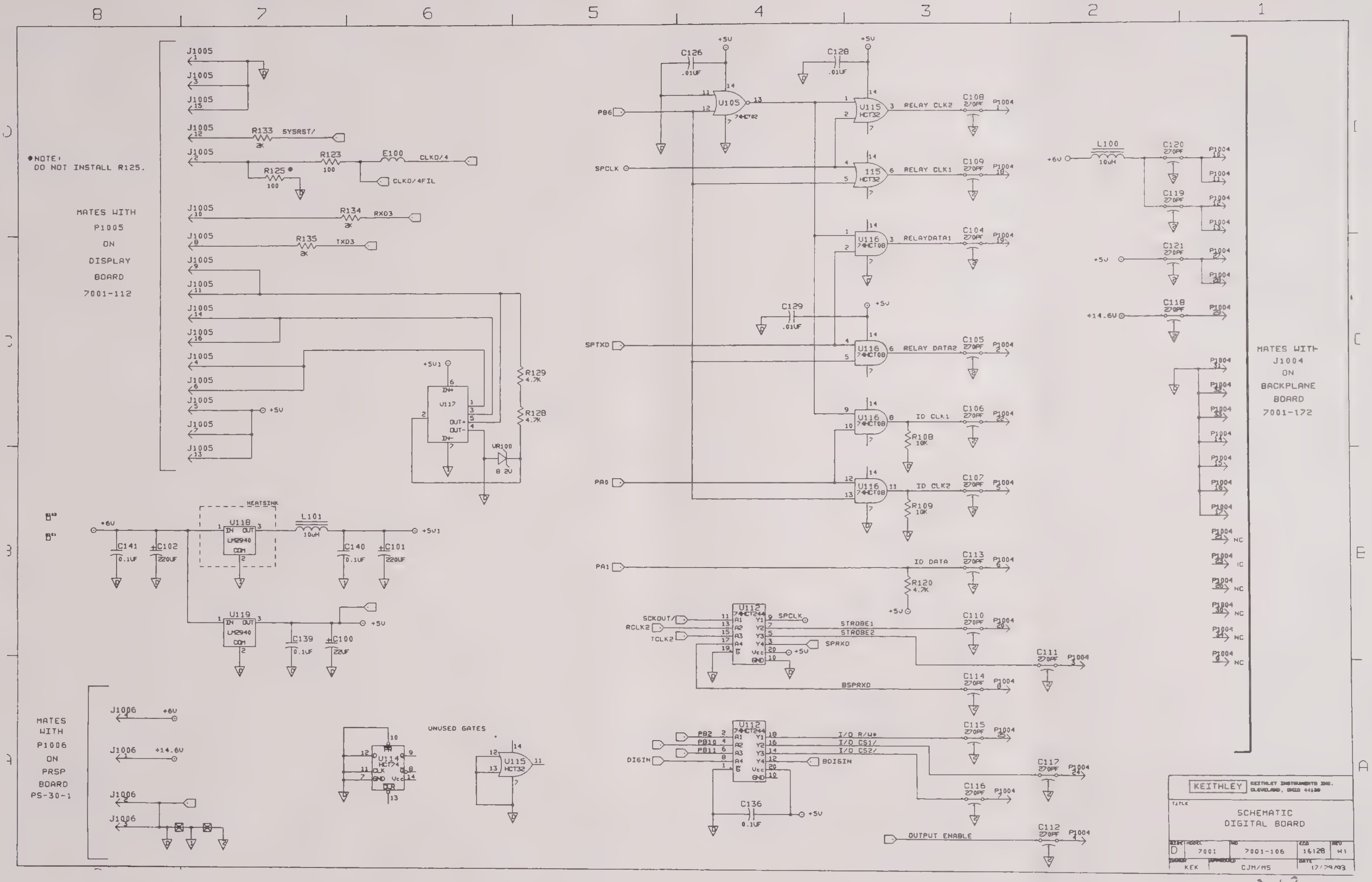
● DO NOT INSTALL JUMPERS W100 & W101

KEITHLEY
KEITHLEY INSTRUMENTS INC
CLEVELAND, OHIO 44139

TITLE
SCHEMATIC
DIGITAL BOARD

SIZE	MODEL	NO	ECO	REV
D	7001	7001-106	16128	M1

DRAWN	APPROVED	DATE
KEK	CJM/MS	12-29-93


8
7
6
5
4
3
2
1
D
C
B
A
J1005
SYSRST/
R133 2K
R123 100
E100
CLKO/4
CLKO/4FIL
R125 100
*NOTE: DO NOT INSTALL R125.
MATES WITH P1005 ON DISPLAY BOARD 7001-112
R134 2K
RXD3
R135 2K
TXD3
+5V
+5V1
U117
IN+
IN-
OUT+
OUT-
R129 4.7K
R128 4.7K
VR100 8.2V
HEATSINK
+6V
U118 LM2940
IN OUT COM
L101 10uH
C141 0.1UF
C102 220UF
C140 0.1UF
C101 220UF
U119 LM2940
C139 0.1UF
C100 22UF
MATES WITH P1006 ON PRSP BOARD PS-30-1
J1006
+14.6V
UNUSED GATES
U114 HCT74
PR CLK GND Vcc CLR
U115 HCT32
C126 .01UF
C128 .01UF
C129 .01UF
PB6
SPCLK
SPTXD
PA0
PA1
U105 74HCT02
U115 HCT32
U116 74HCT08
RELAY CLK2
RELAY CLK1
RELAYDATA1
RELAY DATA2
ID CLK1
ID CLK2
ID DATA
R108 10K
R109 10K
R120 4.7K
C108 270PF
C109 270PF
C104 270PF
C105 270PF
C106 270PF
C107 270PF
C113 270PF
C110 270PF
C111 270PF
C114 270PF
C115 270PF
C117 270PF
C116 270PF
C112 270PF
C136 0.1UF
P1004
SCKOUT/
RCLK2
TCLK2
U112 74HCT244
SPCLK
STROBE1
STROBE2
SPRXD
BSPRXD
PB2
PB10
PB11
DIGIN
I/O R/W*
I/O CS1/
I/O CS2/
BDIGIN
OUTPUT ENABLE
L100 10uH
C120 270PF
C119 270PF
C121 270PF
C118 270PF
+14.6V
NC
MATES WITH J1004 ON BACKPLANE BOARD 7001-172

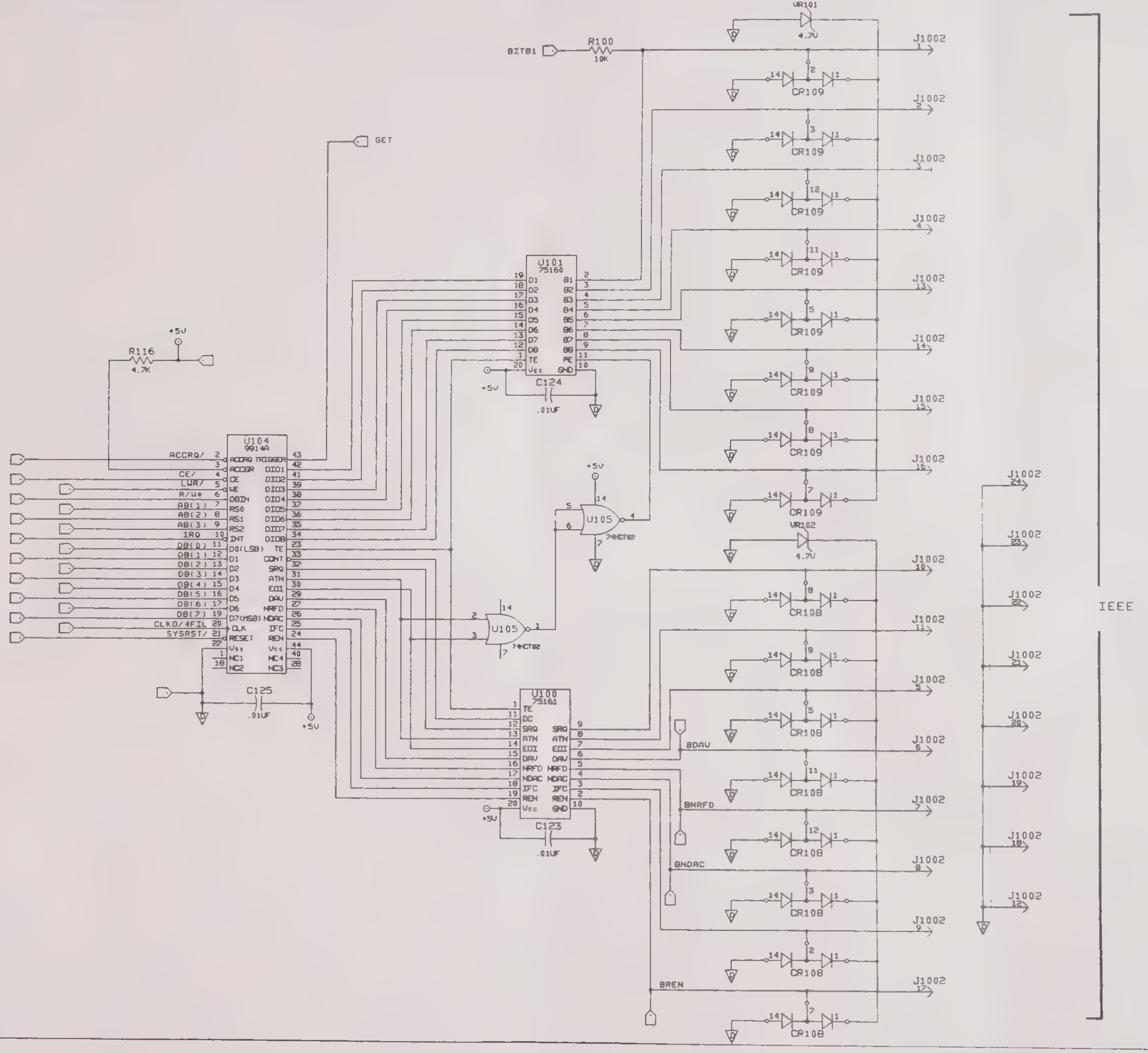
KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139

TITLE
SCHEMATIC
DIGITAL BOARD

SIZE	MODEL	NO.	ECO	REV
D	7001	7001-106	16128	H1

DESIGN	DRAWN/CHKD	DATE
KEK	CJM/MS	12/29/93

2 of 3


8
7
6
5
4
3
2
1
D
C
B
A
VR101
4.7V
BIT81
R100
10K
J1002
1
CR109
14
2
1
2
3
12
11
5
9
8
7
13
14
15
16
GET
U101
75160
D1
D2
D3
D4
D5
D6
D7
D8
TE
Vcc
B1
B2
B3
B4
B5
B6
B7
B8
PE
GND
C124
.01UF
+5V
R116
4.7K
U104
9914A
ACCRQ/
CE/
LWR/
R/W*
AB(1)
AB(2)
AB(3)
IRQ
DB(0)
DB(1)
DB(2)
DB(3)
DB(4)
DB(5)
DB(6)
DB(7)
CLKO/4FIL
SYSRST/
ACCRQ
ACCGR
CE
WE
DBIN
RS0
RS1
RS2
INT
D0(LSB)
D1
D2
D3
D4
D5
D6
D7(MSB)
CLK
RESET
Vss
NC1
NC2
TRIGGER
DIO1
DIO2
DIO3
DIO4
DIO5
DIO6
DIO7
DIO8
TE
CONT
SRQ
ATN
EOI
DAV
NRFD
NDAC
IFC
REN
Vcc
NC4
NC3
C125
.01UF
U105
74HCT02
VR102
4.7V
CR108
10
11
5
6
7
8
9
17
24
23
22
21
20
19
18
12
U100
75161
TE
DC
SRQ
ATN
EOI
DAV
NRFD
NDAC
IFC
REN
Vcc
GND
C123
.01UF
BDAV
BNRFD
BNDAC
BREN
IEEE

KEITHLEY
KEITHLEY INSTRUMENTS INC
CLEVELAND, OHIO 44139

TITLE
SCHEMATIC
DIGITAL BOARD

SIZE	MODEL	NO.	ECO	REV
D	7001	7001-106	16128	H1

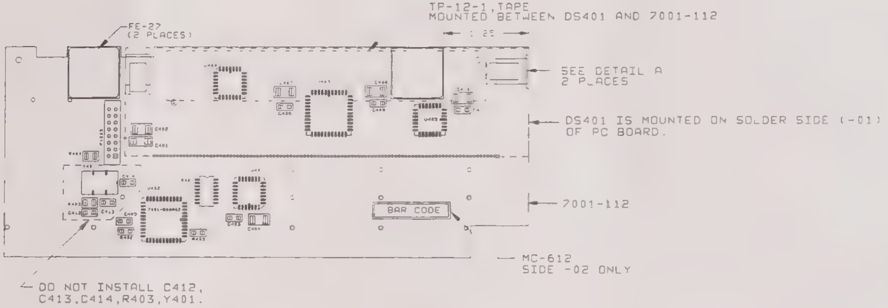
DRAWN	APPROVED	DATE
KEK	CJM/MS	12/29/93

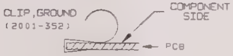
3 of 3

Table 8-2
Display Board, Parts List

Circuit desig.	Description	Keithley part no.
	DISPLAY BOARD ASSEMBLY	7001-110
	VACUUM FLUORESCENT DISPLAY	DD-51
	CLIP, GROUND	2001-352
C401	CAP,22UF, 20%, 6.3,TANTALUM(C6032)	C-417-22
C402,404,407,408,410	CAP, .1UF, 20%,100V, CERAMIC (1812)	C-436-.1
C403,405,406,409,411	CAP,.1UF, 20%,50V,CERAMIC(1206)	C-418-.1
P1005	CABLE ASSEMBLY, 16-PIN RIBBON CABLE	CA-27-14
R401	RES NET, 15K, 2%, 1.875W(SOMIC)	TF-219-15K
R402	RES, 13K, 5%,125MW, METAL FILM(1206)	R-375-13K
R404	RES,100,5%,250MW,METAL FILM(1210)	R-376-100
R405	RES,10K,5%,125MW,METAL FILM(1206)	R-375-10K
U401,404,405	IC, LATCHED DRIVERS,UCN-5812EPF-1(PLCC)	IC-732
U402	PROGRAM	7001-800A01
U403	IC, 32-BIT, SERIAL UCN5818EPF-1(PLCC)	IC-830

LTR.	ECO NO.	REVISION	ENG.	DATE
B	14774	RELEASED	MS	8-27-91
C	14843	CHG'D ARTWORK FROM REV B TO C.	AS	1-9-92
D	15578	CHG'D ARTWORK FROM REV C TO D.	AS	12-21-92
D1	16802	ADDED 7001-800A02.	SZ	11-1-94
D2	16924	ADDED (2) FE-27'S		3-2-95


FE-27
(2 PLACES)
TP-12-1, TAPE
MOUNTED BETWEEN DS401 AND 7001-112
1.25
SEE DETAIL A
2 PLACES
DS401 IS MOUNTED ON SOLDER SIDE (-01)
OF PC BOARD.
BAR CODE
7001-112
MC-612
SIDE -02 ONLY
DO NOT INSTALL C412,
C413, C414, R403, Y401.


CLIP, GROUND
(2001-352)
COMPONENT
SIDE
PCB

DETAIL A

NOTE: FOR MORE COMPONENT INFORMATION REFER TO MODEL 7001 PRODUCT STRUCTURE.

MODEL	NEXT ASSEMBLY	QTY.
USED ON		

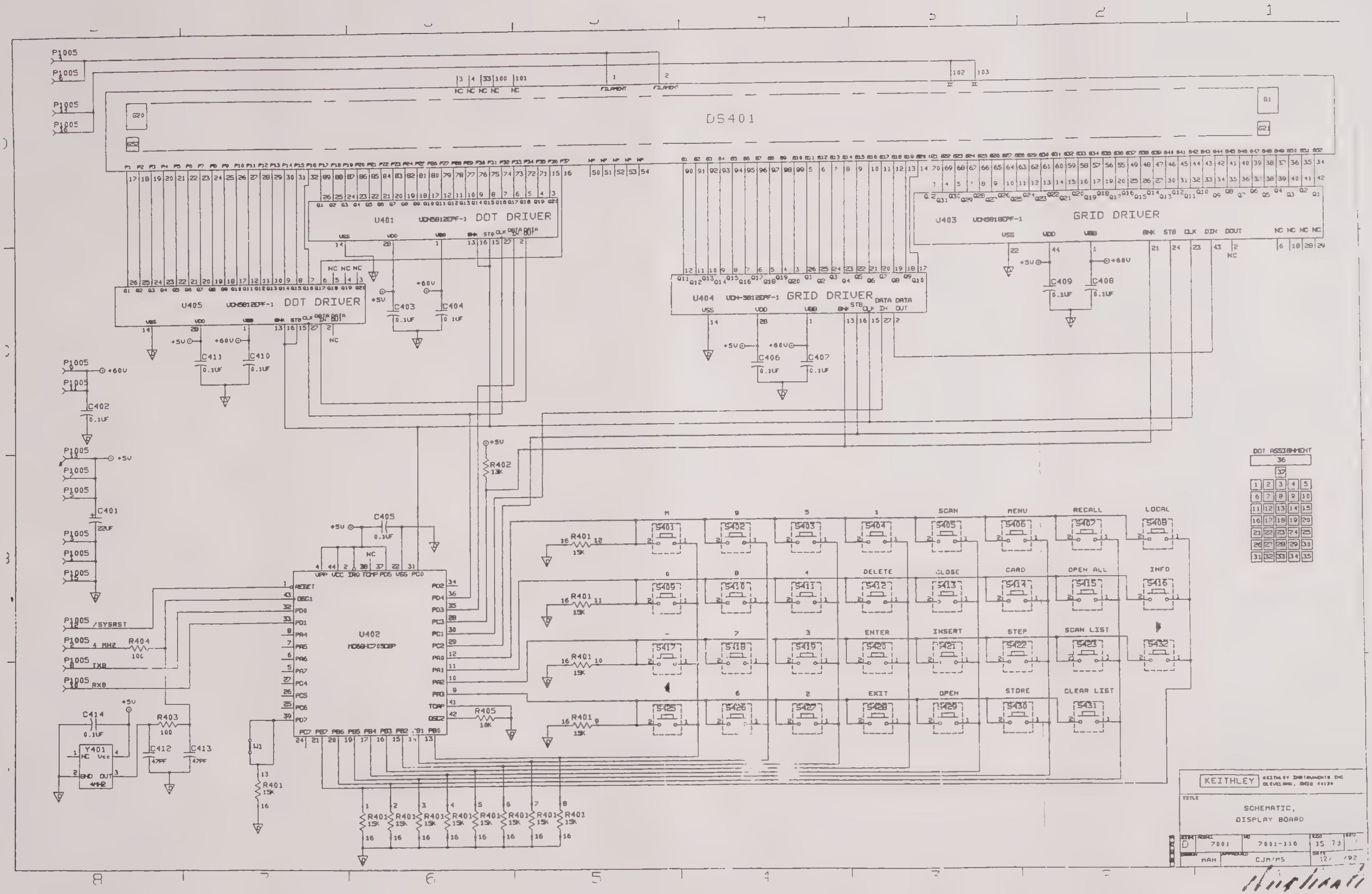
DO NOT SCALE THIS DRAWING

KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		DATE 7/23/91	SCALE 1:1
XX=±.015	ANG.=±1°	DRN. MAH	ENG APPR. CM/MS
XXX=±.005	FRAC.=±1/64	MATERIAL N/A	
SURFACE MAX 63		FINISH N/A	

TITLE COMPONENT LAYOUT, DISPLAY BOARD

C NO. 7001-110


DS401
P1005
FILAMENT
G20
G52
G1
G21
U401 UCN5812EPF-1 DOT DRIVER
U405 UCN5812EPF-1 DOT DRIVER
U403 UCN5818EPF-1 GRID DRIVER
U404 UCN-5812EPF-1 GRID DRIVER
VSS VDD VBB BNK STB CLK DATA IN DATA OUT
+5V
+60V
C401 22UF
C402 0.1UF
C403 0.1UF
C404 0.1UF
C405 0.1UF
C406 0.1UF
C407 0.1UF
C408 0.1UF
C409 0.1UF
C410 0.1UF
C411 0.1UF
C412 47PF
C413 47PF
C414 0.1UF
R401 15K
R402 10K
R403 100
R404 100
R405 10K
Y401 4MHZ
W1
/SYSRST
4 MHZ
TXB
RXB
U402 MC68HC705C8P
RESET OSC1 PD0 PD1 PA4 PA5 PA6 PA7 PC4 PC5 PC6 PD7
VPP VCC IRQ TCMP PD5 VSS PC0
PD2 PD4 PD3 PC3 PC1 PC2 PA0 PA1 PA2 PA3 TCAP OSC2
PC7 PB7 PB6 PB5 PB4 PB3 PB2 PB1 PB0
NC
M
9
5
1
SCAN
MENU
RECALL
LOCAL
0
8
4
DELETE
CLOSE
CARD
OPEN ALL
INFO
-
7
3
ENTER
INSERT
STEP
SCAN LIST
6
2
EXIT
OPEN
STORE
CLEAR LIST
S401
S402
S403
S404
S405
S406
S407
S408
S409
S410
S411
S412
S413
S414
S415
S416
S417
S418
S419
S420
S421
S422
S423
S432
S425
S426
S427
S428
S429
S430
S431
DOT ASSIGNMENT
36
37
1 2 3 4 5
6 7 8 9 10
11 12 13 14 15
16 17 18 19 20
21 22 23 24 25
26 27 28 29 30
31 32 33 34 35
8 7 6 5 4 3 2 1

KEITHLEY
KEITHLEY INSTRUMENTS INC
CLEVELAND, OHIO 44139

TITLE
SCHEMATIC,
DISPLAY BOARD

D | 7001 | 7001-116 | 15 73

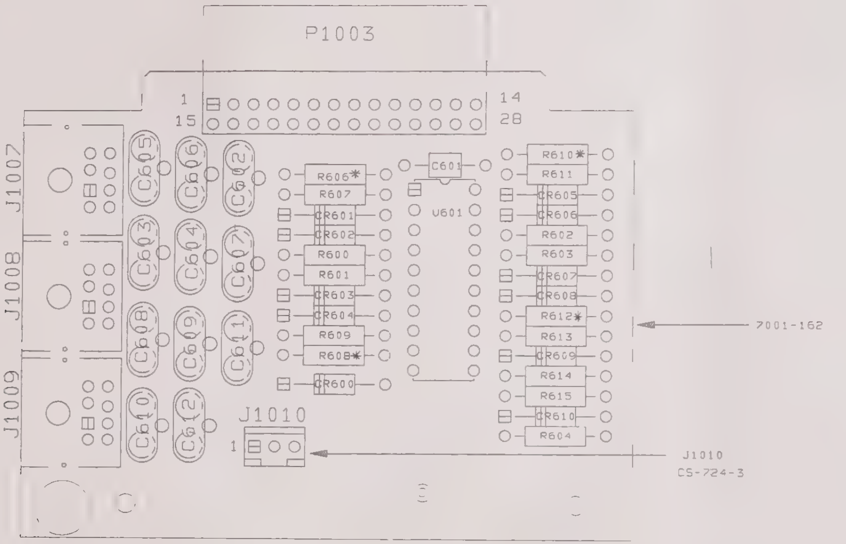
MAH | CJM/MS | 12/ /92

Table 8-3
Micro DIN Board, Parts List

Circuit desig.	Description	Keithley part no.
	MICRO DIN AND BNC BOARD ASSEMBLY	7001-250
C602-612	CAP,270PF,20%,100V,CERAMIC/FERRITE	C-386-270P
C601	CAP,.1UF,20%,50V,CERAMIC	C-365-.1
CR600-610	DIODE,SILICON,1N4148 (DO-35)	RF-28
J1007-1009	CONN, CIRCULAR DIN	CS-762
J1010	LATCHING HEADER,FRICTON, SGL ROW	CS-724-3
P1003	CONNECTOR, PIN STRIP	CS-776-28
R600-604	RES,10,1%,1/8W,METAL FILM	R-88-10
R606-614	RES,10K,1%,1/8W,METAL FILM	R-88-10K
R615	RES,2K,1%,1/8,METAL FILM	R-88-2K
U601	IC,8-CHANNEL SAT SINK DRIVER,UDN-2596A	IC-578

NO. 7001-160

LTR.	ECO NO.	REVISION	ENG.	DATE
B	910304	RELEASED		3-4-91
C	14779	REVISED (formerly 704-160)	MS	9-5-91
[illegible]	15177	CHG D ARTWORK REV FROM C TO D	AS	9-29-92
D1	17052	REMOVED MC-612 SIDE 01		[illegible]
D2	18206	ADDED * DO NOT POPULATE R606,R608 R610 R6[illegible]		7-14-96


P1003
1
14
15
28
J1007
J1008
J1009
C605
C606
C602
C603
C604
C607
C608
C609
C611
C610
C612
R606*
R607
CR601
CR602
R600
R601
CR603
CR604
R609
R608*
CR600
C601
U601
R610*
R611
CR605
CR606
R602
R603
CR607
CR608
R612*
R613
CR609
R614
R615
CR610
R604
J1010
1
7001-162
J1010
CS-724-3

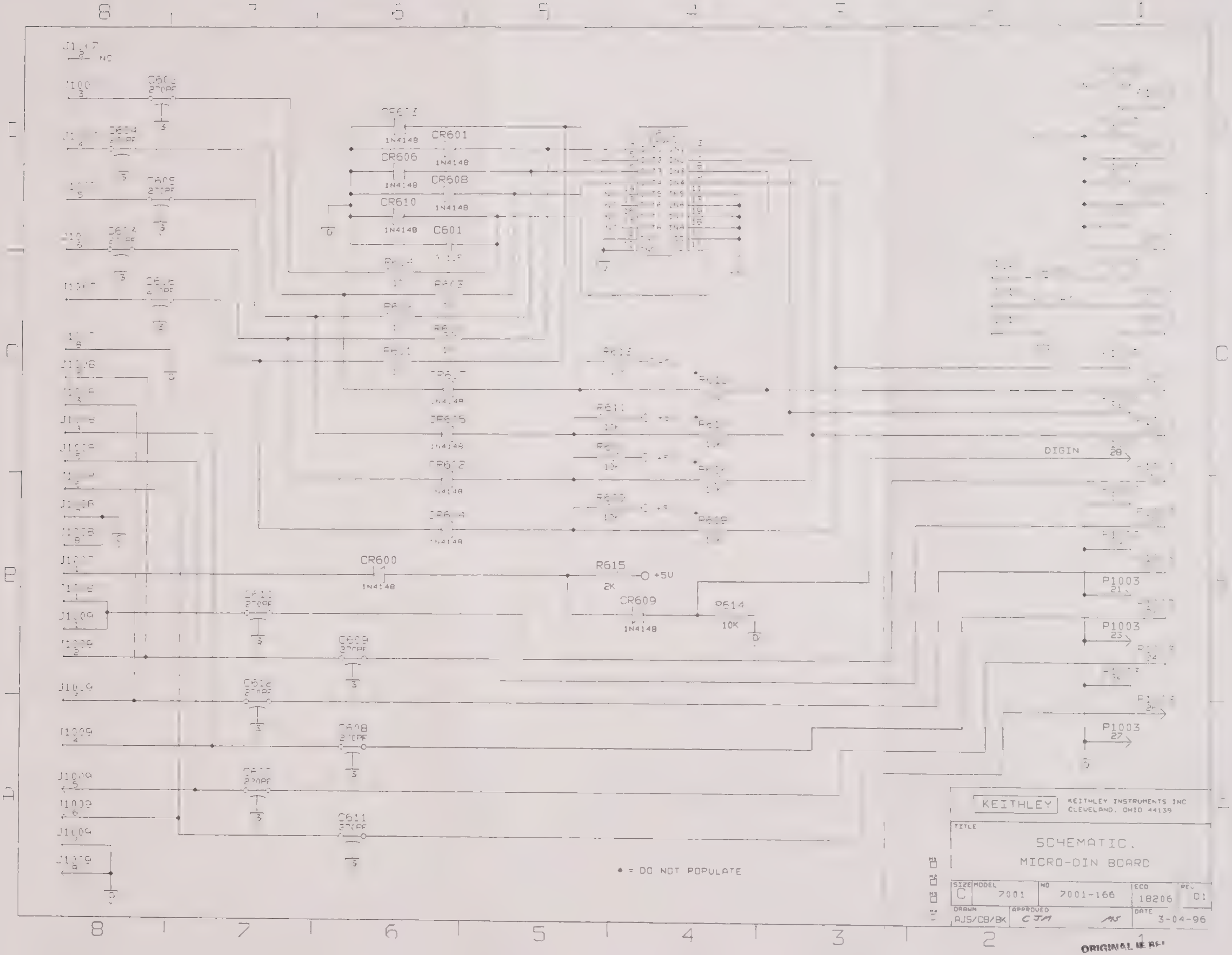
* = DO NOT POPULATE R606, R608, R610, R612

NOTE:

FOR COMPONENT INFORMATION,
REFER TO MODEL 7001 PRODUCT STRUCTURE.

7001	
MODEL	NEXT ASSEMBLY
USED ON	

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 2-17-91	SCALE 3:1	TITLE COMPONENT LAYOUT, MICRO-DIN BOARD
KEITHLEY KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	XX=±.015 ANG.=±1°	DRN. AJS/CB	ENG. WJK APPR. MS CJM	
	XXX=±.005 FRAC.=±1/64	MATERIAL		C
	SURFACE MAX. 63	FINISH		NO 7001-160


J1007
NC
270PF
CR601
CR606
CR608
CR610
C601
1N4148
CR600
R615
+5V
2K
CR609
R614
10K
DIGIN
28
P1003
21
23
27
C609
C608
C611
J1009
8
7
6
5
4
3
2
1
D
C
B
A

• = DO NOT POPULATE

KEITHLEY
KEITHLEY INSTRUMENTS INC
CLEVELAND, OHIO 44139

TITLE
SCHEMATIC,
MICRO-DIN BOARD

SIZE	MODEL	NO	ECO	REV
C	7001	7001-166	18206	D1
DRAWN	APPROVED		DATE	
AJS/CB/BK	CJM	MS	3-04-96	

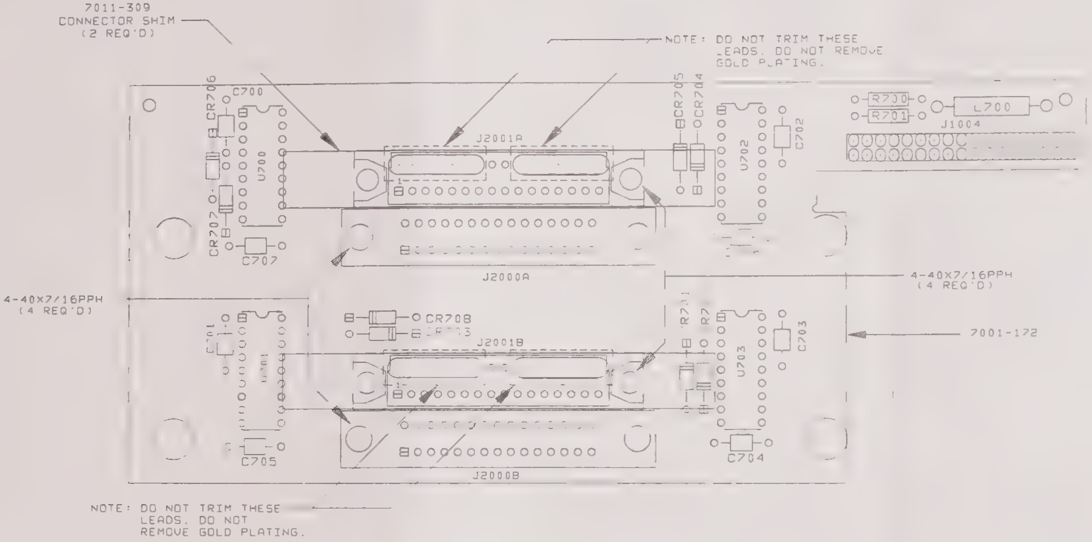
ORIGINAL IE REV

Table 8-4
Backplane Board, Parts List

Circuit desig.	Description	Keithley part no.
	BACKPLANE AND EXTENDER BOARD ASSEMBLY	7001-250
	CONNECTOR SHIM	7011-309
C700-707	CAP,.1UF,20%,50V,CERAMIC	C-365-.1
CR701-708	DIODE,SILICON, 1N4148 (DO-35)	RF-28
I700	BEAD, FERRITE	CT-9
J1004	CONN, 34-PIN, 2 ROWS	CS-771-34
J2000A,J2000B	CONN, 30-PIN EDGE	CS-454-2
J2001A, J2001B	CONN, 32-PIN, 3 ROWS	CS-748-2
R700,701	RES, 1.8K,5%,1/4W,COMPOSITION OR FILM	R-76-1.8K
U700-703	IC, 8 STAGE SHIFT/STORE UCN5841	IC-536

NO. 7001-170

LTR.	ECO NO.	REVISION	ENG	DATE
B	910304	RELEASED		3-4-91
C	14779	REVISED	MS	9-5-91
D	14825	CHG D ARTWORK FROM REV C TO D. ADDED (2) 7011-309 CONNECTOR SHIM	AS	12-18-91
D1	15069	ADDED TRIM LEADS NOTE	SZ	2-5-92
E	15177	ARTWORK WAS REV D. CHG D (4) 2-56X1/4PPH TO 4-40X7/16PPH. REVISED LEAD TRIM NOTES	AS	10-28-92
[illegible]	17052	REMOVED MC-612		[illegible]


7011-309
CONNECTOR SHIM
(2 REQ'D)
NOTE: DO NOT TRIM THESE LEADS. DO NOT REMOVE GOLD PLATING.
CR706
C700
U700
CR707
C707
J2001A
J2000A
CR705
CR704
U702
C702
R700
R701
L700
J1004
4-40X7/16PPH
(4 REQ'D)
CR708
CR703
J2001B
J2000B
C701
U701
C705
R702
R703
U703
C703
C704
7001-172
NOTE: DO NOT TRIM THESE LEADS. DO NOT REMOVE GOLD PLATING.

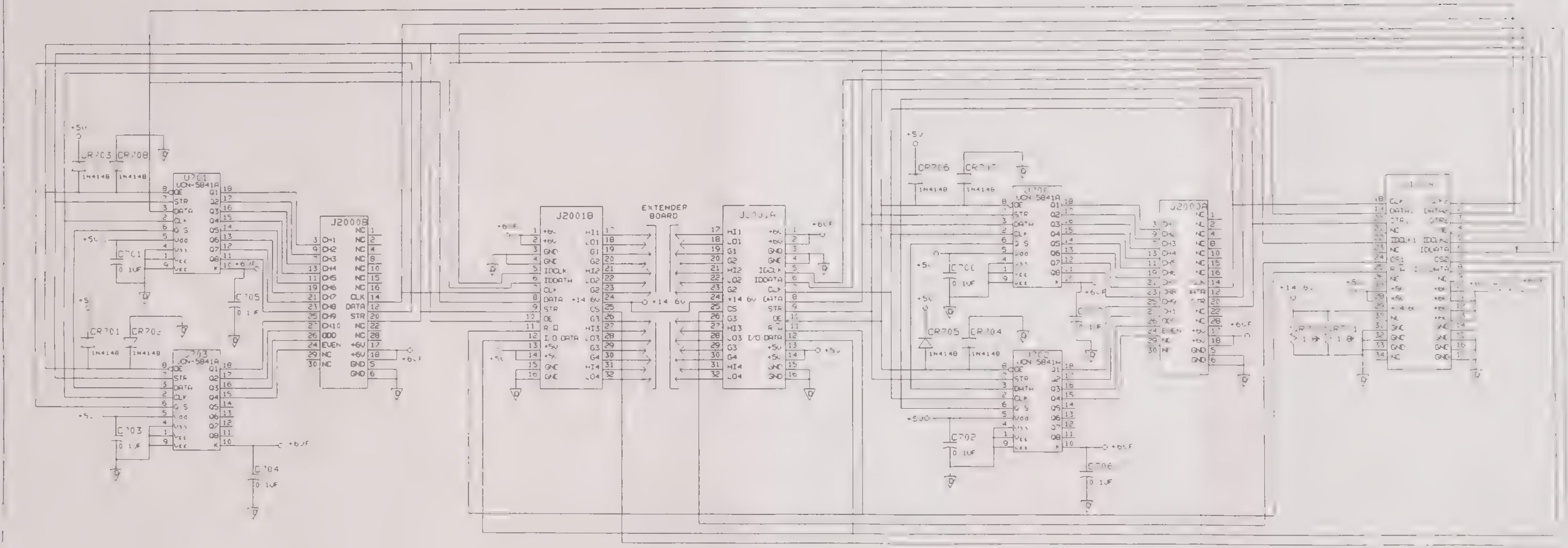
NOTES:

FOR COMPONENT INFORMATION, REFER TO MODEL 7001 PRODUCT STRUCTURE

TRIM LEADS TO .040 MAX, EXCEPT WHERE NOTED.

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		
KEITHLEY KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	XX=±.015	ANG.=±1°	DRN.
	XXX=±.005	FRAC.=±1/64	MATERIAL
	SURFACE MAX. 63		FINISH

ORIGINAL


U701
UCN-5841A
U703
UCN-5841A
U702
UCN-5841A
J2000B
J2001B
EXTENDER
BOARD
J2000A
CR701
CR702
CR703
CR704
CR705
CR706
CR708
1N4148
C701
C702
C703
C704
C705
C706
0.1UF
+5V
+6VF
+14.6V
DATA
STR
CLK
IDCLK
IDDATA
GND

KEITHLEY | KEITHLEY INSTRUMENTS INC
CLEVELAND OHIO 44139

TITLE
SCHEMATIC
BACKPLANE BOARD

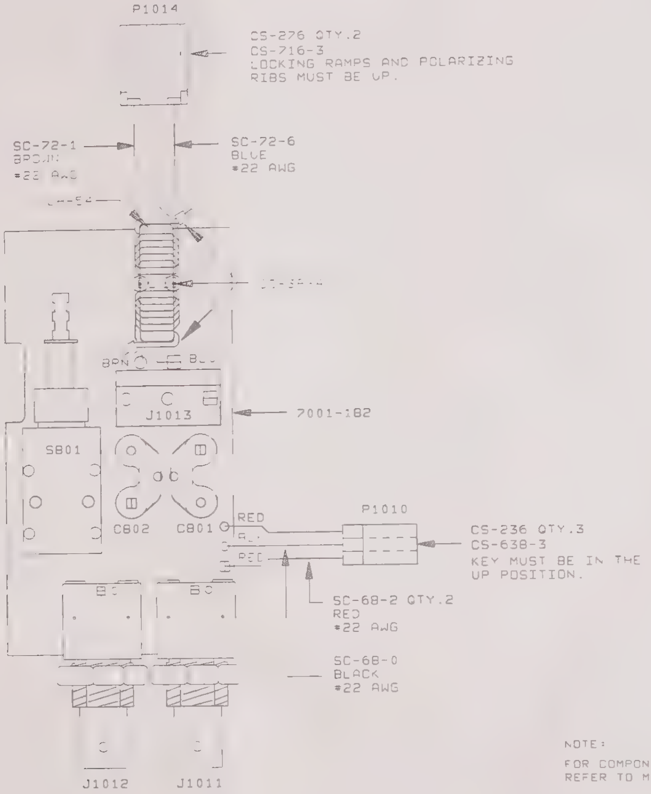
7001-176

Table 8-5
BNC Board, Parts List

Circuit desig.	Description	Keithley part no.
	MICRO DIN AND BNC BOARD ASSEMBLY	7001-250
	CHOKE	CH-54
	FOR CH-54 ASSY CABLE CLAMP	CC-38-4
	CH-54 ASSY TO BD CABLE CLAMP	CC-38-4
C801,802	CAP, 3000P, 20%, 250V EMI SUPP FILTER	C-475-3000P
J1011,1012	CONN, BNC	CS-547
J1013	CONN,MOLEX, 5-PIN	CS-772-5
S801	SWITCH,PUSHBUTTON (6 POLE)	SW-466

NO. 7001-180

LTR.	ECO NO.	REVISION
B	910304	RELEASED
C	14779	REVISED
C1	17052	REMOVED MC-612 SIDE 01
D	20393	ARTWORK WAS REV C


P1014
CS-276 QTY.2
CS-716-3
LOCKING RAMPS AND POLARIZING RIBS MUST BE UP.
SC-72-1
BROWN
#22 AWG
SC-72-6
BLUE
#22 AWG
BRN
BLU
J1013
7001-182
S801
C802
C801
RED
RED
P1010
CS-236 QTY.3
CS-638-3
KEY MUST BE IN THE UP POSITION.
SC-68-2 QTY.2
RED
#22 AWG
SC-68-0
BLACK
#22 AWG
J1012
J1011

NOTE:

FOR COMPONENT INFORMATION
REFER TO MODEL 7001 PRODUCT STRUCTURE.

MODEL	NEXT ASSEMBLY	QTY
USED ON		

DO NOT SCALE THIS DRAWING

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX=±.015 ANG.=±1°
XXX=±.005 FRAC.=±1/64
SURFACE MAX. 63

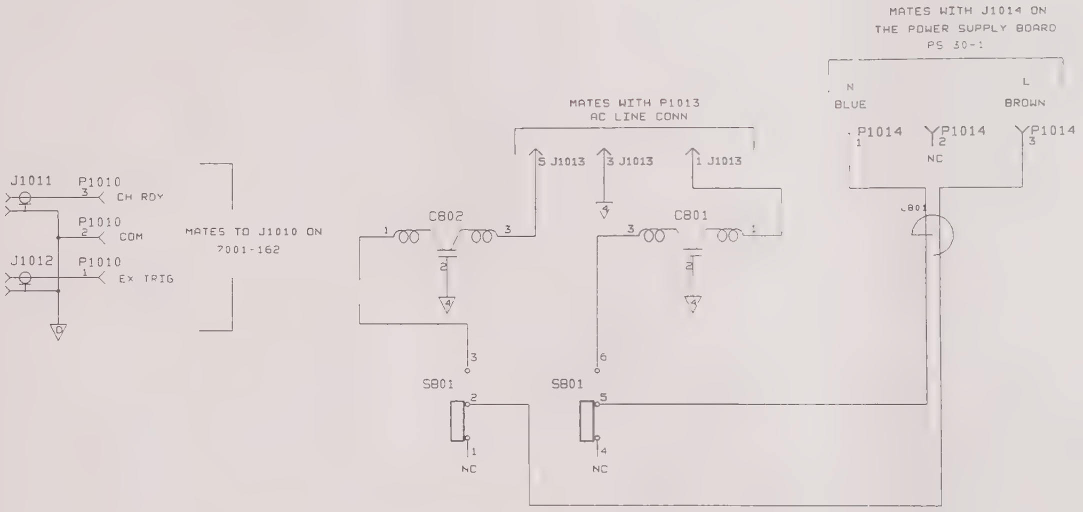
DATE 8/22/91 SCALE 2:1
DRN. MAH ENG. APPR.
MATERIAL
FINISH

TITLE
COMPONENT LAYOUT
BNC BOARD

C [illegible]

KEITHLEY
KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139

ORIGINAL IF RED


MATES WITH J1014 ON
THE POWER SUPPLY BOARD
PS 30-1
N
L
BLUE
BROWN
P1014 1
P1014 2
P1014 3
NC
MATES WITH P1013
AC LINE CONN
5 J1013
3 J1013
1 J1013
4
J1011
P1010
3
CH RDY
P1010
2
COM
J1012
P1010
1
EX TRIG
MATES TO J1010 ON
7001-162
C802
1
3
2
4
C801
3
1
2
4
L801
3
6
S801
2
1
NC
S801
5
4
NC
8
7
6
5
4
3
2
1
D
C
B
A

KEITHLEY

KEITHLEY INSTRUMENTS INC.
CLEVELAND, OHIO 44139

TITLE

SCHEMATIC
BNC BOARD

SIZE	MODEL	NO	ECO	REV
C	7001	7001-186		

Appendices

Appendix A — Interface Function Codes

Appendix B — ASCII Character Codes and IEEE-488 Multiline Interface Command Messages

Appendix C — Controller Programs

Appendix D — IEEE-488 Bus Overview

Appendix E — IEEE-488 Conformance Information

Appendix F — SCPI Conformance Information

A

Interface Function Codes

The interface function codes, which are part of the IEEE-488 standards, define an instrument's ability to support various interface functions and should not be confused with programming commands found elsewhere in this manual. The interface function codes for the Model 7001 are listed in Table C-1. The codes define Model 7001 capabilities as follows:

SH (Source Handshake Function) — SH1 defines the ability of the instrument to initiate the transfer of message/data over the data bus.

AH (Acceptor Handshake Function) — AH1 defines the ability of the instrument to guarantee proper reception of message/data transmitted over the data bus.

T (Talker Function) — The ability of the instrument to send data over the bus to other devices is provided by the T function. Instrument talker capabilities (T5) exist only after the instrument has been addressed to talk.

L (Listener Function) — The ability for the instrument to receive device-dependent data over the bus from other devices is provided by the L function. Listener capabilities (L4) of the instrument exist only after it has been addressed to listen.

SR (Service Request Function) — SR1 defines the ability of the instrument to request service from the controller.

RL (Remote-Local Function) — RL1 defines the ability of the instrument to be placed in the remote or local modes.

PP (Parallel Poll Function) — The instrument does not have parallel polling capabilities (PP0).

DC (Device Clear Function) — DC1 defines the ability of the instrument to be cleared (initialized).

DT (Device Trigger Function) — DTI defines the ability of the Model 182 to have readings triggered.

C (Controller Function) — The instrument does not have controller capabilities (C0).

TE (Extended Talker Function) — The instrument does not have extended talker capabilities (TE0).

LE (Extended Listener Function) — The instrument does not have extended listener capabilities (LE0).

E (Bus Driver Type) — The instrument has open-collector bus drivers (E1).

Table A-1
Model 7001 interface function codes

Code	Interface function
SH1	Source Handshake capability
AH1	Acceptor Handshake capability
T5	Talker (basic talker, serial poll, unaddressed to talk on LAG)
L4	Listener (basic listener, unaddressed to listen on TAG)
SR1	Service Request capability
RL1	Remote/Local capability
PP0	No Parallel Poll capability
DC1	Device Clear capability
DT1	Device Trigger capability
C0	No Controller capability
E1	Open collector bus drivers
TE0	No Extended Talker capability
LE0	No Extended Listener capability

B

ASCII Character Codes and IEEE-488 Multiline Interface Command Messages

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
0	00	NUL	
1	01	SOH	GTL
2	02	STX	
3	03	ETX	
4	04	EOT	SDC
5	05	ENQ	PPC
6	06	ACK	
7	07	BEL	
8	08	BS	GET
9	09	HT	TCT
10	0A	LF	
11	0B	VT	
12	0C	FF	
13	0D	CR	
14	0E	SO	
15	0F	SI	
16	10	DLE	
17	11	DC1	LLO
18	12	DC2	
19	13	DC3	
20	14	DC4	DCL
21	15	NAK	PPU
22	16	SYN	
23	17	ETB	
24	18	CAN	SPE
25	19	EM	SPD
26	1A	SUB	
27	1B	ESC	
28	1C	FS	
29	1D	GS	
30	1E	RS	
31	1F	US	

* Message sent or received with ATN true.

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
32	20	SP	MLA 0
33	21	!	MLA 1
34	22	″	MLA 2
35	23	#	MLA 3
36	24	$	MLA 4
37	25	%	MLA 5
38	26	&	MLA 6
39	27	′	MLA 7
40	28	(	MLA 8
41	29	)	MLA 9
42	2A	*	MLA 10
43	2B	+	MLA 11
44	2C	′	MLA 12
45	2D	-	MLA 13
46	2E	.	MLA 14
47	2F	/	MLA 15
48	30	0	MLA 16
49	31	1	MLA 17
50	32	2	MLA 18
51	33	3	MLA 19
52	34	4	MLA 20
53	35	5	MLA 21
54	36	6	MLA 22
55	37	7	MLA 23
56	38	8	MLA 24
57	39	9	MLA 25
58	3A	:	MLA 26
59	3B	;	MLA 27
60	3C	<	MLA 28
61	3D	=	MLA 29
62	3E	>	MLA 30
63	3F	?	UNL

* Message sent or received with ATN true. Numbers shown represent primary address resulting in MLA (My Listen Address).

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
64	40	@	MTA 0
65	41	A	MTA 1
66	42	B	MTA 2
67	43	C	MTA 3
68	44	D	MTA 4
69	45	E	MTA 5
70	46	F	MTA 6
71	47	G	MTA 7
72	48	H	MTA 8
73	49	I	MTA 9
74	4A	J	MTA 10
75	4B	K	MTA 11
76	4C	L	MTA 12
77	4D	M	MTA 13
78	4E	N	MTA 14
79	4F	O	MTA 15
80	50	P	MTA 16
81	51	Q	MTA 17
82	52	R	MTA 18
83	53	S	MTA 19
84	54	T	MTA 20
85	55	U	MTA 21
86	56	V	MTA 22
87	57	W	MTA 23
88	58	X	MTA 24
89	59	Y	MTA 25
90	5A	Z	MTA 26
91	5B	[	MTA 27
92	5C	\	MTA 28
93	5D	]	MTA 29
94	5E	«	MTA 30
95	5F	æ	UNL

* Message sent or received with ATN true. Numbers shown are primary address resulting in MTA (My Talk Address).

Decimal	Hexadecimal	ASCII	IEEE-488 Messages*
96	60	«	MSA 0, PPE
97	61	a	MSA 1, PPE
98	62	b	MSA 2, PPE
99	63	c	MSA 3, PPE
100	64	d	MSA 4, PPE
101	65	e	MSA 5, PPE
102	66	f	MSA6, PPE
103	67	g	MSA 7, PPE
104	68	h	MSA 8, PPE
105	69	i	MSA 9, PPE
106	6A	j	MSA 10, PPE
107	6B	k	MSA 11, PPE
108	6C	l	MSA 12, PPE
109	6D	m	MSA 13, PPE
110	6E	n	MSA 14, PPE
111	6F	o	MSA 15, PPE
112	70	p	MSA 16, PPD
113	71	q	MSA 17, PPD
114	72	r	MSA 18, PPD
115	73	s	MSA 19, PPD
116	74	t	MSA 20, PPD
117	75	u	MSA 21, PPD
118	76	v	MSA 22, PPD
119	77	w	MSA 23, PPD
120	78	x	MSA 24, PPD
121	79	y	MSA 25, PPD
122	7A	z	MSA 26, PPD
123	7B	{	MSA 27, PPD
124	7C	|	MSA 28, PPD
125	7D	}	MSA 29, PPD
126	7E	~	MSA 30, PPD
127	7F	DEL	

* Message sent or received with ATN true. Numbers represent secondary address resulting in MSA (My Secondary Address).

C

Controller Programs

The following programs have been supplied as a simple aid to the user and are not intended to suit specific needs. Each program allows you to send a command message to the instrument and obtain and display a response from the instrument for query commands.

Programs for the following controllers are included:

- A BASIC program for an IBM PC/XT/AT with a Capital Equipment Corporation PC<>488 Interface (Keithley Model PC-488-CEC IEEE-488 Interface Card).
- A BASIC program for an IBM PC/XT/AT with IOtech Driver488 Software.
- A BASIC program for a Hewlett-Packard Model 9000 Series 200/300 computer.
- A program written with the ASYST software package (available from Keithley Instruments) for an IBM PC/XT/AT with a Capital Equipment Corporation PC<>488 Interface.
- A BASIC program for an IBM PC/XT/AT with a National GPIB PC Interface.

IBM PC/XT/AT with Capital Equipment Corporation PC<>488 Interface (Keithley PC-488-CEC)

Introduction

General information about controlling a Model 7001 with an IBM PC/XT/AT computer and Capital Equipment Corporation PC<>488 interface is given here. Refer to the CEC PC<>488 Programming and Reference Manual for complete information.

Initializing the system

The first step in any program is to initialize the system using the INITIALIZE routine. This routine sets the primary IEEE-488 bus address of the PC<>488, specifies the type of controller to be used, and sends an interface clear (IFC) to the other devices on the bus.

After booting up the IBM using DOS and entering BASICA, the statements of Program 1 can be used at the start of any program to initialize the system.

Line 30 sets the address of the PC<>488 to 21, however, any other valid address could be used as long as it does not conflict with the address of any other device on the bus.

Interface basic programming statements

This paragraph covers the PC<>488 statements that are essential to Model 7001 operation. A partial list of programming statements is contained in Table E-1. The IBM BASIC CALL statement is used to execute the desired action. Before a CALL routine can be used, BASIC needs to know the offset address of the routine. In the table, the first statement of each programming sequence defines the offset address of the CALL routine.

Example program

The following program sends a command message from an IBM PC/XT/AT computer to the Model 7001 and displays the response to a query on the CRT. The computer must be equipped with a CEC interface card and DOS 2.0 (or later revision) operating system.

Directions

1. Using the front panel MENU key, set the primary IEEE-488 address of the Model 7001 (GPIB selection) to 7.
2. With the power off, connect the Model 7001 to the IEEE-488 interface card installed in the IBM computer.
3. Type in BASICA on the computer keyboard to get into interpretive BASIC language.
4. Enter the lines of Program 2 using the return key after each line.
5. Run the program and type in the desired command string at the ENTER COMMAND MESSAGE prompt. For example, to request the currently defined Scan List, type in :SCAN? and press the return key. The Scan List will appear on the computer CRT.

Table C-1
BASIC statements necessary to send bus commands

Action	PC<>488 statements
Transmit command string (CMD$) to device 7.	SEND =9 ADDRESS%=7 CALL SEND(ADDRESS%,CMD$,STATUS%)
Obtain string from device 7.	ENTER=21 ADDRESS%=7 RESPONSE$=SPACE$(50) CALL ENTER(RESPONSE$,LENGTH%,ADDRESS%,STATUS%)
Send GTL to device 7.	TRANSMIT=3 CMD$="LISTEN 7 GTL" CALL TRANSMIT(CMD$,STATUS%)
Send SDC to device 7.	TRANSMIT=3 CMD$="LISTEN 7 SDC" CALL TRANSMIT(CMD$,STATUS%)
Send DCL to all devices.	TRANSMIT=3 CMD$="LISTEN 7 DCL" CALL TRANSMIT(CMD$,STATUS%)
Send remote enable.	TRANSMIT=3 CMD$="REN LISTEN 7" CALL TRANSMIT(CMD$,STATUS%)
Serial poll device 7.	SPOLL=12 ADDRESS%=7 CALL SPOLL%(ADDRESS%,POLL%,STATUS%)

```
10  DEF=SEG&HC400                   ' Memory address.
20  INITIALIZE=0                    ' Offset address of routine.
30  MY.ADDRESS%=21                  ' Set PC<>488 address.
40  CONTROLLER%=0                   ' Set for system control.
50  CALL INITIALIZE (MY.ADDRESS%,   ' Initilize system.
    CONTROLLER%)
```

Program 1

```
10  DEF SEG=&HC400                       ' Memory address.
20  INITIALIZE=0                         ' Define call offsets.
30  SEND=9:ENTER=21
40  MY.ADDRESS%=21                       ' Set PC<>488 address.
50  INST.ADDRESS%=7                      ' Set 7001 address.
60  CONTROLLER%=0                        ' Set for system control.
70  CALL INITIALIZE (MY.ADDRESS%,        ' Initialize system.
    CONTROLLER%)
80  LINE INPUT "ENTER COMMAND            ' Prompt for command message.
    MESSAGE ";CMD$
90  CALL SEND (INST.ADDRESS%, CMD$       ' send command message.
    STATUS%)
100 IF RIGHT$(CMD$, 1) <> "?"            ' Test for query. If command is a
    THEN GOTO 80                           query, goto 80.
110 RESPONSE$=SPACE$(80)                 ' Make room for data.
120 CALL ENTER (RESPONSE$,LENGTH%,       ' Get response to query from 7001.
    INST.ADDRESS%,STATUS%)
130 PRINT RESPONSE$                      ' Display response to query.
140 GOTO 80                              ' Display response to query.
150 END
```

Program 2

IBM PC/XT/AT or PS/2 with IOtech Driver488 Software

Introduction

Driver488 software is an IEEE-488 driver for IBM PC and compatible computers. When combined with an IEEE-488 interface board, the package can control devices from languages including BASIC, Pascal, Fortran, and C. Driver488 software is compatible with:

- IOtech GP488B or GP488/2 boards
- National Instruments GPIB-PC, PCII, PCIIA, or PCIII boards
- Capital Equipment #01000-00300 board
- IBM GPIB Adapter

The following GW-BASIC program sends a command message to the Model 7001 and displays the instrument response for queries on the CRT. The computer must be equipped with an IEEE-488 interface board, the DOS 3.00 (or later) operating system, and a language with DOS I/O capability. Driver488 controller software must be installed and configured as described in the instruction manual.

Directions

1. Using the front panel MENU key and the GPIB menu item, set the primary address of the Model 7001 to 7.
2. With power off, connect the Model 7001 to the IEEE-488 interface installed in the IBM computer.
3. Type in GWBASIC on the computer and get into the Microsoft interpretive BASIC language.
4. Enter the lines below using the return key after each line.
5. Run the program and type in the desired command string at the ENTER COMMAND MESSAGE prompt. For example, to request the currently defined Scan List, type in :SCAN? and press the return key. The Scan List will appear on the computer CRT.

```
10  OPEN "\DEV\IEEEOUT" FOR OUTPUT AS #1           ' Open file for output.
20  IOCTL#1,"BREAK"                                ' Reset
30  PRINT#1,"RESET"
40  OPEN "\DEV\IEEEIN" FOR INPUT AS #2             ' Open file for input.
50  PRINT#1, "FILL ERROR"                          ' Enable SEQUENCE error detect.
60  LINE INPUT "ENTER COMMAND MESSAGE ";A$         ' Prompt for an get commands.
70  IF LEN(A$)=0 THEN 140                          ' Check for null.
80  PRINT #1,"OUTPUT 07;"+A$                       ' Send commands.
90  IF RIGHT$(A$, 1)<> "?" THEN GOTO 60            ' Check for query.
100 PRINT #1,"ENTER 07"                            ' Address 7001 to talk.
110 LINE INPUT#2,B$                                ' Get response.
120 PRINT B$                                       ' Display response message.
130 goto 60                                        ' Repeat.
140 END
```

Hewlett-Packard Model 9000 Series 200/300

Introduction

The following program sends a command message to the Model 7001 from a Hewlett-Packard Model 9000 Series 200/300 computer and displays the response to queries on the computer CRT. The computer must be equipped with HP BASIC 4.0.

Directions

1. Using the front panel MENU key and the GPIB menu item, set the primary IEEE-488 address of the Model 7001 to 7.
2. With the power off, connect the Model 7001 to the IEEE-488 interface card installed in the HP computer.
3. Enter the lines in the program below, using the ENTER/RETURN key after each line.
4. Press the RUN key and type in the desired command string at the ENTER COMMAND MESSAGE prompt. For example, to request the currently defined Scan List, type in :SCAN? and press the return key. The Scan List will appear on the computer CRT.

```
10  DIMA$[50], B$[50]
20  remote 707                                     ! Place 7001 in remote.
30  LINPUT “ENTER COMMAND MESSAGE”, A$             ! Prompt for command.
40  OUTPUT 707; A$                                 ! Address 7001 to listen; send command.
50  L=LEN(A$)
60  IF A$[L,L] <> “?” THEN GOTO 30                 ! If command is not a query, goto 30.
70  ENTER 707; B$                                  ! If query, address 7001 to talk.
80  PRINT B$                                       ! Display response to query command.
90  GOTO 30                                        ! Repeat
100 END
```

IBM PC/XT/AT or Compatible with CEC PC<>488 Interface and ASYST Software

Introduction

ASYST contains analysis, graphing, and data acquisition software in three integrated modules. Minimum requirements for ASYST include:

- IBM PC/XT/AT or 100% compatible (including PS/2, 386 or 486-based computers in real mode)
- DOS 2.0 (DOS 3.0 or above recommended)
- Intel 8087, 80287, or 80387 math coprocessor
- 640K RAM
- 25-pin parallel port
- Hard disk and one floppy
- IBM CGA, EGA, VGA, or 100% compatible; Hercules monochrome graphics
- LIM (Lotus/Intel/Microsoft) expanded memory is recommended

For this example, an optional software module is required for IEEE-488 interfacing. The computer must also be equipped with a CEC interface card (PC<>488 Model 300 or 310, or 4 x 488).

The ASYST program listed here sends a command string from an IBM computer to the Model 7001 and displays the response for queries on the computer's CRT.

Directions

1. Using the front panel menu, set the primary address of the Model 7001 to 07.
2. With the power off, connect the Model 7001 to the IEEE-488 interface card installed in the IBM computer.
3. Boot ASYST software. Enter the Main Configuration Menu: use the <F2> key from the OK prompt, or select CONFIG from the menu bar.
4. In addition to the usual configuration requirements of ASYST, the GPIB must be configured. From the Overlay Configuration menu, select GPIB from the Available Overlays list; then select GPIB Master and Type 1 NEC GPIB driver from the pop-up menu.
5. From the GPIB Configuration menu, select a bus number, the board number for a Capital Equipment PC<>488 (NEC uPD7210 type), a primary address (0), the hexadecimal I/O address (2B8, also known as the memory address), and an unused interrupt line.
6. Save your changes and return to the OK prompt or the menu bar.
7. Use the command line editor to enter the example program. From the OK prompt, type EDIT 7001.DMO; from the menu bar, select EDIT and type 7001.DMO. Save the program and exit the editor.
8. When prompted, load the program with the L key, or type LOAD 7001.DMO from the OK prompt.
9. When the program loads properly, type MAIN from the OK prompt to start execution.
10. Type in the desired command string at the "Enter command string:" prompt. For example, to close multiplexer channels, type in :CLOS (@1!1:1!5) and press the return key. The Model 7001 will show closed channels on card 1. To query for closed channels, type in :CLOS:STAT? and press the return key. The Model 7001 closed channel list will then appear on the computer display.
11. Type <Control-Break> to exit the program loop of 7001.DMO and return to the OK prompt. The program-defined words can be removed from the ASYST dictionary by typing FORGET 7001.

```
BUS.INIT                                \ Initialize bus
SEND.INTERFACE.CLEAR                    \ TAKE CONTROL OF BUS
REMOTE.ENABLE.ON                        \ Allow remote operation
SYNCHRONOUS.GPIB                        \ Make sure ASYST is in sync. mode
?GPIB.DEVICES                           \ List controller parameters
07 GPIB.DEVICE 7001                     \ Set 7001 address and name
   EOI.ON                               \ Enable end or identify
   EOS.ON                               \ Enable end of string terminator
   10 EOS.CHARACTER                     \ Use LF terminator
   1000 TIMEOUT                         \ Set timeout for 1sec
?GPIB.DEVICE                            \ List 7001 parameters
100 STRING COMMAND                      \ Allocate 100 bytes for user input
100 STRING RESPONSE                     \ Allocate 100 bytes for 7001 response

:GET.OUTPUT                             \ Definition for 7001 output
   RESPONSE GPIB.READ                   \ Get response
   CR RESPONSE "TYPE                    \ Display response
;

: GET.INPUT                             \ Definition for user input
   CR ." Enter command string: "        \ Prompt user
   "INPUT COMMAND ":=                   \ Get commands
   "?" COMMAND "WITHIN                  \ Test for query
   IF 7001                              \ If query, make 7001 current device
      COMMAND GPIB.WRITE                \ Send commands to 7001
      GET.OUTPUT                        \ Get response from 7001
   ELSE 7001                            \ If not query, make 7001 current device
      COMMAND GPIB.WRITE                \ Send commands to 7001
   THEN
;

: MAIN                                  \ Definition for main program
  BEFIN                                 \ Start loop
  ME                                    \ Make controller current device
  GET.INPUT                             \ Get commands from user
  AGAIN                                 \ Return for more commands
;                                       \ <Control-Break> to exit
```

IBM PC/XT/AT with National GPIB PC Interface

Introduction

The following program sends a command message to the Model 7001 from an IBM PC/XT/AT computer and displays a response message on the CRT. The computer must be equipped with the National GPIB PC Interface and the DOS 2.00 (or later revision) operating system. Interface software must be installed and configured as described in the instruction manual.

Directions

1. Using the front panel MENU key and the GPIB menu item, set the primary address of the Model 7001 to 7.
2. With the power off, connect the Model 7001 to the IEEE-488 interface installed in the IBM computer.
3. Type in BASICA on the computer keyboard to get into the IBM interpretive BASIC language.
4. Place the interface software disk in the default drive, type LOAD "DECL", and press the return key.
5. Add the lines below to lines 1-6 which are now in memory. Modify the address in lines 1 and 2, as described in the National instruction manual.
6. Run the program and type in the desired command message. For example, to request the currently defined Scan List, type in :SCAN? and press the return key. The Scan List will appear on the computer CRT.

```
10  CLS                                          Clear screen.
20  NA$="GPIB0":CALL IBFIND (NA$,BRD0%)          Find board descriptor.
30  NA$="DEV1":CALL IBFIND(NA$,M7001%)           Find instrument descriptor.
40  V%=7:CALL IBPAD(M7001%,V%)                   Set primary address to 7.
50  V%=&H102:CALL IBPOKE(BRD0%,V%)               Set timeouts.
60  V%=1:CALL IBSRE(BRD0%,V%)                    Set REN true.
70  INPUT “ENTER COMMAND MESSAGE “:CMD$          Prompt for command.
80  IF CMD$="EXIT" THEN 160                      See if program is to be halted.
90  IF CMD$+ “ “ THEN 70                         Check for null input.
100 CALL IBWRT (M7001%,CMD$)                     Send command message.
110 IF RIGHT$(CMD$, 1) <> “>" THEN GOTO 70       Check for query command.
120 RD$=SPACE$(100)                              Define reading input buffer.
130 CALL IBRD(M7001%,RD$)                        Address 7001 to talk.
140 PRINT RD$                                    Display message response.
150 GOTO 70                                      Repeat.
160 V%=0:CALL IBONL(M7001%,V%)                   Close the instrument file.
170 CALL IBONL(BRD0%,V%)
180 END
```

D

IEEE-488 Bus Overview

Introduction

Basically, the IEEE-488 bus is simply a communication system between two or more electronic devices. A device can be either an instrument or a computer. When a computer is used on the bus, it serves to supervise the communication exchange between all the devices and is known as the controller. Supervision by the controller consists of determining which device will talk and which device will listen. As a talker, a device will output information and as a listener, a device will receive information. To simplify the task of keeping track of the devices, a unique address number is assigned to each one.

On the bus, only one device can talk at a time and is addressed to talk by the controller. The device that is talking is known as the active talker. The devices that need to listen to the talker are addressed to listen by the controller. Each listener is then referred to as an active listener. Devices that do not need to listen are instructed to unlisten. The reason for the unlisten instruction is to optimize the speed of bus information transfer since the task of listening takes up bus time.

Through the use of control lines, a handshake sequence takes place in the transfer process of information from a talker to a listener. This handshake sequence helps ensure the credibility of the information transfer. The basic handshake sequence between an active controller (talker) and a listener is as follows:

1. The listener indicates that it is ready to listen.
2. The talker places the byte of data on the bus and indicates that the data is available to the listener.
3. The listener, aware that the data is available, accepts the data and then indicates that the data has been accepted.
4. The talker, aware that the data has been accepted, stops sending data and indicates that data is not being sent.
5. The listener, aware that there is no data on the bus, indicates that it is ready for the next byte of data.

Bus Description

The IEEE-488 bus, which is also frequently referred to a the GPIB (General Purpose Interface Bus), was designed as a parallel transfer medium to optimize data transfer without using an excessive number of bus lines. In keeping with this goal, the bus has only eight data lines that are used for both data and with most commands. Five bus management lines and three handshake lines round out the complement of bus signal lines

A typical set up for controlled operation is shown in Figure D-1. Generally, a system will contain one controller and a number of other instruments to which the commands are given. Device operation is categorized into three operators: controller, talker and listener. The controller does what its name implies; it controls the instruments on the bus. The talker sends data while a listener receives data. Depending on the type of instrument, any particular device can be a talker only, a listener only or both a talker and listener.

There are two categories of controllers: system controller, and basic controller. Both are able to control other instruments, but only the system controller has the absolute authority in the system. In a system with more than one controller, only one controller may be active at any given time. Certain protocol is used to pass control from one controller to another.

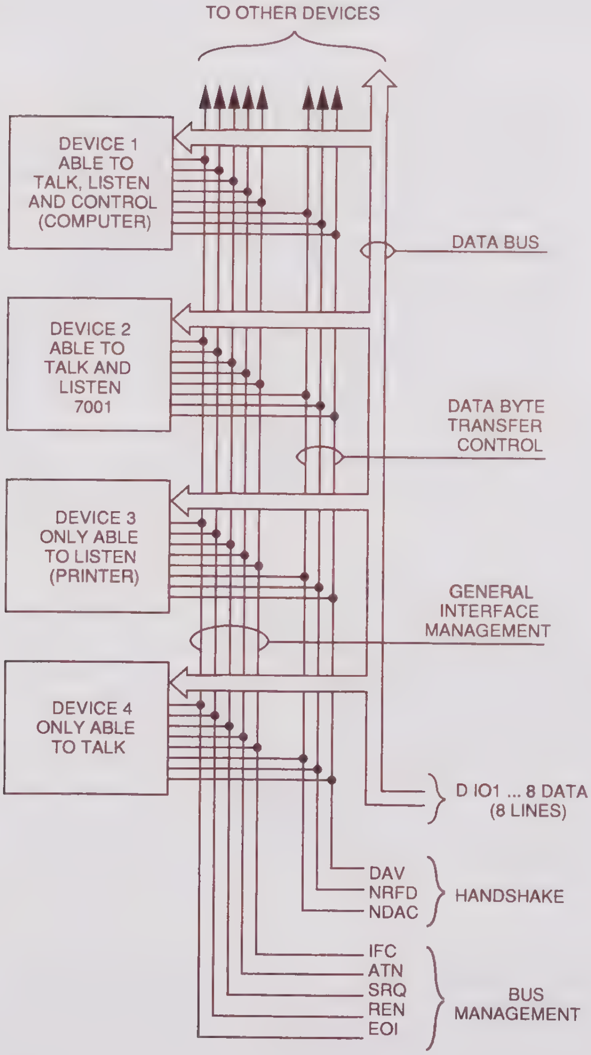

TO OTHER DEVICES
DEVICE 1 ABLE TO TALK, LISTEN AND CONTROL (COMPUTER)
DATA BUS
DEVICE 2 ABLE TO TALK AND LISTEN 7001
DATA BYTE TRANSFER CONTROL
DEVICE 3 ONLY ABLE TO LISTEN (PRINTER)
GENERAL INTERFACE MANAGEMENT
DEVICE 4 ONLY ABLE TO TALK
D IO1 ... 8 DATA (8 LINES)
DAV
NRFD
NDAC
HANDSHAKE
IFC
ATN
SRQ
REN
EOI
BUS MANAGEMENT

Figure D-1
IEEE-488 bus configuration

The IEEE-488 bus is limited to 15 devices, including the controller. Thus, any number of talkers and listeners up to that limit may be present on the bus at one time. Although several devices may be commanded to listen simultaneously, the bus can have only one active talker, or communications would be scrambled.

A device is placed in the talk or listen state by sending an appropriate talk or listen command. These talk and listen commands are derived from an instrument's primary address. The primary address may have any value between 0 and 31, and is generally set by rear panel DIP switches or programmed in from the front panel of the instrument. The actual listen address value sent out over the bus is obtained by ORing the primary address with $20. For example, if the primary address is 27 decimal ($07), the actual listen address is $27 ($27 = $07 + $20). In a similar manner, the talk address is obtained by ORing the primary address with $40. With the present example, the talk address derived from a primary address of 7 decimal would be $47 ($47 = $07 + $40).

The IEEE-488 standards also include another addressing mode called secondary addressing. Secondary addresses lie in the range of $60-$7F. Note, however, that many devices, including the Model 7001, do not use secondary addressing.

Once a device is addressed to talk or listen, the appropriate bus transactions take place. For example: if the instrument is addressed to talk, it places its data string on the bus one byte at a time. The controller reads the information and the appropriate software can be used to direct the information to the desired location.

Bus Lines

The signal lines on the IEEE-488 bus are grouped into three different categories: data lines, management lines and handshake lines. The data lines handle bus data and commands, while the management and handshake lines ensure that proper data transfer and operation takes place. Each bus line is active low, with approximately zero volts representing a logic 1 (true). The following paragraphs describe the operation of these lines.

Data lines

The IEEE-488 bus uses eight data lines that transfer data one byte at a time. DIO1 (Data Input/Output) through DIO8 (Data Input/Output) are the eight data lines used to transmit both data and multiline commands and are bidirectional. The data lines operate with low true logic.

Bus management lines

The five bus management lines help to ensure proper interface control and management. These lines are used to send the uniline commands.

ATN (Attention) — The ATN line is one of the more important management lines in that the state of this line determines how information on the data bus is to be interpreted.

IFC (Interface Clear) — As the name implies, the IFC line controls clearing of instruments from the bus.

REN (Remote Enable) —The REN line is used to place the instrument on the bus in the remote mode.

EOI (End or Identify) — The EOI is usually used to mark the end of a multi-byte data transfer sequence.

SRQ (Service Request) — This line is used by devices when they require service from the controller.

Handshake lines

The bus handshake lines operate in an interlocked sequence. This method ensures reliable data transmission regardless of the transfer rate. Generally, data transfer will occur at a rate determined by the slowest active device on the bus.

One of the three handshake lines is controlled by the source (the talker sending information), while the remaining two lines are controlled by accepting devices (the listener or listeners receiving the information). The three handshake lines are:

DAV (DATA VALID) — The source controls the state of the DAV line to indicate to any listening devices whether or not data bus information is valid.

NRFD (Not Ready For Data) — The acceptor controls the state of NRFD. It is used to signal to the transmitting device to hold off the byte transfer sequence until the accepting device is ready.

NDAC (Not Data Accepted) — NDAC is also controlled by the accepting device. The state of NDAC tells the source whether or not the device has accepted the data byte.

The complete handshake sequence for one data byte is shown in Figure D-2. Once data is placed on the data lines, the source checks to see that NRFD is high, indicating that all active devices are ready. At the same time, NDAC should be low from the previous byte transfer. If these conditions are not met, the source must wait until NDAC and NRFD have the correct status. If the source is a controller, NRFD and NDAC must be stable for at least 100nsec after ATN is set true. Because of the possibility of a bus hang up, many controllers have time-out routines that display messages in case the transfer sequence stops for any reason.

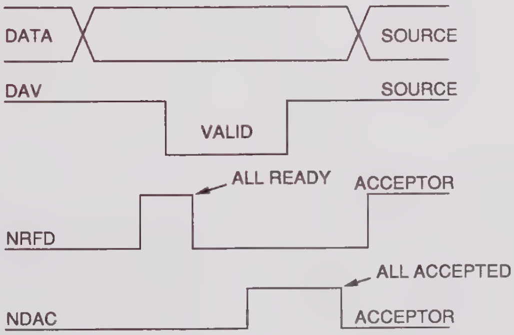


Figure D-2
IEEE-488 handshake sequence

Once all NDAC and NRFD are properly set, the source sets DAV low, indicating to accepting devices that the byte on the data lines is now valid. NRFD will then go low, and NDAC will go high once all devices have accepted the data. Each device will release NDAC at its own rate, but NDAC will not be released to go high until all devices have accepted the data byte.

The sequence just described is used to transfer both data, talk and listen addresses, as well as multiline commands. The state of the ATN line determines whether the data bus contains data, addresses or commands as described in the following paragraph..

Bus Commands

The instrument may be given a number of special bus commands through the IEEE-488 interface. This section briefly describes the purpose of the bus commands which are grouped into the following three categories.

1. Uniline Commands — Sent by setting the associated bus lines true. For example, to assert REN (Remote Enable), the REN line would be set low (true).
2. Multiline Commands — General bus commands which are sent over the data lines with the ATN line true (low).
3. Common Commands — Commands that are common to all devices on the bus; sent with ATN high (false).
4. SCPI Commands — Commands that are particular to each device on the bus; sent with ATN (false).

These bus commands and their general purpose are summarized in Table D-1.

Uniline commands

ATN, IFC and REN are asserted only by the controller. SRQ is asserted by an external device. EOI may be asserted either by the controller or other devices depending on the direction of data transfer. The following is a description of each command. Each command is sent by setting the corresponding bus line true.

REN (Remote Enable) — REN is sent to set up instruments on the bus for remote operation. When REN is true, devices will be removed from the local mode. Depending on device configuration, all front panel controls except the LOCAL button (if the device is so equipped) may be locked out when REN is true. Generally, REN should be sent before attempting to program instruments over the bus.

EOI (End or Identify) — EOI is used to positively identify the last byte in a multi-byte transfer sequence, thus allowing data words of various lengths to be transmitted easily.

IFC (Interface Clear) — IFC is used to clear the interface and return all devices to the talker and listener idle states.

ATN (Attention) — The controller sends ATN while transmitting addresses or multiline commands.

SRQ (Service Request) — SRQ is asserted by a device when it requires service from a controller.

Universal multiline commands

Universal commands are those multiline commands that require no addressing. All devices equipped to implement such commands will do so simultaneously when the commands are transmitted. As with all multiline commands, these commands are transmitted with ATN true.

LLO (Local Lockout) — LLO is sent to the instrument to lock out the LOCAL key and thus all their front panel controls.

DCL (Device Clear) — DCL is used to return instruments to some default state. Usually, instruments return to their power-up conditions.

SPE (Serial Poll Enable) — SPE is the first step in the serial polling sequence which is used to determine which device has requested service.

SPD (Serial Poll Disable) — SPD is used by the controller to remove all devices on the bus from the serial poll mode and is generally the last command in the serial polling sequence.

Table D-1
IEEE-488 bus command summary

Command type	Command	State of ATN line	Comments
Uniline	REN (Remote Enable)	X	Set up devices for remote operation.
	EOI	X	Marks end of transmission.
	IFC (Interface Clear)	X	Clears interface.
	ATN (Attention)	Low	Defines data bus contents.
	SRQ	X	Controlled by external device.
Multiline Universal	LLO (Local Lockout)	Low	Locks our local operation.
	DCL (Device Clear)	Low	Returns device to default conditions.
	SPE (Serial Enable)	Low	Enables serial polling.
	SPD (Serial Poll Disable)	Low	Disables serial polling.
Addressed	SDC (Selective Device Clear)	Low	Returns unit to default conditions.
	GTL (Go To Local)	Low	Returns device to local.
Unaddressed	UNL (Unlisten)	Low	Removes all listeners from the bus.
	UNT (Untalk)	Low	Removes any talkers from the bus.
Common	—	High	Programs IEEE-488.2 compatible instruments for common operations.
SCPI	—	High	Programs SCPI compatible instruments for particular operations.

Addressed multiline commands

Addressed commands are multiline commands that must be preceded by the device listen address before that instrument will respond to the command in question. Note that only the addressed device will respond to these commands. Both the commands and the address preceding it are sent with ATN true.

SDC (Selective Device Clear) — The SDC command performs essentially the same function as the DCL command except that only the addressed device responds. Generally, instruments return to their power-up default conditions when responding to the SDC command.

GTL (Go To Local) — The GTL command is used to remove instruments from the remote mode. With some instruments, GTL also unlocks front panel controls if they were previously locked out with the LLO command.

GET (Group Execute Trigger) — The GET command is used to trigger devices to perform a specific action that depends on device configuration (for example, take a reading). Although GET is an addressed command, many devices respond to GET without addressing.

Address commands

Addressed commands include two primary command groups and a secondary address group. ATN is true when these commands are asserted. The commands include:

LAG (Listen Address Group) — These listen commands are derived from an instrument's primary address and are used to address devices to listen. The actual command byte is obtained by ORing the primary address with $20.

TAG (Talk Address Group) — The talk commands are derived from the primary address by ORing the address with $40. Talk commands are used to address devices to talk.

SCG (Secondary Command Group) — Commands in this group provide additional addressing capabilities. Many devices (including the Model 7001) do not use these commands.

Unaddress commands

The two unaddress commands are used by the controller to remove any talkers or listeners from the bus. ATN is true when these commands are asserted.

UNL (Unlisten) — Listeners are placed in the listener idle state by the UNL command.

UNT (Untalk) — Any previously commanded talkers will be placed in the talker idle state by the UNT command.

Common commands

Common commands are commands that are common to all devices on the bus. These commands are designated and defined by the IEEE-488.2 standard.

Generally, these commands are sent as one or more ASCII characters that tell the device to perform a common operation, such as reset. The IEEE-488 bus treats these commands as data in that ATN is false when the commands are transmitted.

SCPI commands

SCPI commands are commands that are particular to each device on the bus. These commands are designated by the instrument manufacturer, and are based on the instrument model defined by the Standard Commands for Programmable Instruments (SCPI) Consortium's SCPI standard.

Generally, these commands are sent as one or more ASCII characters that tell the device to perform a particular operation, such as setting a range or closing a relay. The IEEE-488 bus treats these commands as data in that ATN is false when the commands are transmitted.

Command codes

Command codes for the various commands that use the data lines are summarized in Figure D-3. Hexadecimal and the decimal values for the various commands are listed in Table D-2.

Figure D-3
Command codes

D_7 D_6 D_5 D_4						X 0 0 0	Command	X 0 0 1	Command	X 0 1 0	Primary Address	X 0 1 1	Primary Address	X 0 1 1	Primary Address	X 0 1 1	Primary Address	X 1 1 0		X 1 1 1	
Bits	D_3 ↓	D_2 ↓	D_1 ↓	D_0 ↓	Column→ Row ↓	0 (A)	0 (B)	1 (A)	1 (B)	2 (A)	2 (B)	3 (A)	3(B)	4 (A)	4 (B)	5 (A)	5 (B)	6 (A)	6 (B)	7 (A)	7 (B)
	0	0	0	0	0	NUL		DLE		SP	0	0	16	@	0	P	16			p	
	0	0	0	1	1	SOH	GTL	DC1	LLO	!	1	1	17	A	1	Q	17	a		q	
	0	0	1	0	2	STX		DC2		"	2	2	18	B	2	R	18	b		r	
	0	0	1	1	3	ETX		DC3		#	3	3	19	C	3	S	19	c		s	
	0	1	0	0	4	EOT	SDC	DC4	DCL	$	4	4	20	D	4	T	20	d		t	
	0	1	0	0	5	ENQ	PPC*	NAK	PPU*	%	5	5	21	E	5	U	21	e		u	
	0	1	1	0	6	ACK		SYN		&	6	6	22	F	6	V	22	f		v	
	0	1	1	1	7	BEL		ETB		'	7	7	23	G	7	W	23	g		w	
	1	0	0	0	8	BS	GET	CAN	SPE	(	8	8	24	H	8	X	24	h		x	
	1	0	0	1	9	HT	TCT*	EM	SPD	)	9	9	25	I	9	Y	25	i		y	
	1	0	1	0	10	LF		SUB		•	10	:	26	J	10	Z	26	j		z	
	1	0	1	1	11	VT		ESC		+	11	;	27	K	11	[	27	k		{	
	1	1	0	0	12	FF		FS		,	12	<	28	L	12	\	28	l		:	
	1	1	0	1	13	CR		GS		-	13	=	29	M	13	]	29	m		}	
	1	1	1	0	14	SO		RS		.	14	>	30	N	14	∩	30	n		≅	
	1	1	1	1	15	SI		US		/	15	?	UNL	O	15	—	UNT	o		DEL	

ADDRESSED COMMAND GROUP (ACG)

UNIVERSAL COMMAND GROUP (UCG)

LISTEN ADDRESS GROUP (LAG)

TALK ADDRESS GROUP (TAG)

PRIMARY COMMAND GROUP (PCG)

SECONDARY COMMAND GROUP (SDC)

*PPC (PARALLEL POLL CONFIGURE) PPU (PARALLEL POLL UNCONFIGURE), and TCT (TAKE CONTROL) not implemented by Model 7001.

Note: D_0 = DIO1 ... D_7 = DIO8; X = Don't Care.

Table D-2
Hexadecimal and decimal command codes

Command	Hex value	Decimal value
GTL	01	1
SDC	04	4
GET	08	8
LLO	11	17
DCL	14	20
SPE	18	24
SPD	19	25
LAG	20-3F	32-63
TAG	40-5F	64-95
SCG	60-7F	96-127
UNL	3F	63
UNT	5F	95

Typical command sequences

For the various multiline commands, a specific bus sequence must take place to properly send the command. In particular, the correct listen address must be sent to the instrument before it will respond to addressed commands. Table D-3 lists a typical bus sequence for sending the addressed multiline commands. In this instance, the SDC command is being sent to the instrument. UNL is generally sent as part of the sequence to ensure that no other active listeners are present. Note that ATN is true for both the listen command and the SDC command byte itself

Table D-4 gives a typical common command sequence. In this instance, ATN is true while the instrument is being addressed, but it is set high while sending the common command string.

IEEE command groups

Command groups supported by the Model 7001 are listed in Table D-5. Common commands and SCPI commands are not included in this list.

Table D-3
Typical addressed command sequence

			Data bus		
Step	**Command**	**ATN state**	**ASCII**	**Hex**	**Decimal**
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	'	27	39
3	SDC	Stays low	EOT	04	4
4		Returns high			

*Assumes primary address = 7.

Table D-4
Typical common command sequence

			Data bus		
Step	**Command**	**ATN state**	**ASCII**	**Hex**	**Decimal**
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	'	27	39
3	Data	Set high	*	2A	42
4	Data	Stays high	R	52	82
5	Data	Stays high	S	53	83
6	Data	Stays high	T	54	84

Assumes primary address = 7.

Table D-5
IEEE command groups

HANDSHAKE COMMAND GROUP	
	NDAC = NOT DATA ACCEPTED
	NRFD = NOT READY FOR DATA
	DAV = DATA VALID
UNIVERSAL COMMAND GROUP	
	ATN = ATTENTION
	DCL = DEVICE CLEAR
	IFC = INTERFACE CLEAR
	REN = REMOTE ENABLE
	SPD = SERIAL POLL DISABLE
	SPE = SERIAL POLL ENABLE
ADDRESS COMMAND GROUP	
LISTEN	LAG = LISTEN ADDRESS GROUP
	MLA = MY LISTEN ADDRESS
	UNL = UNLISTEN
TALK	TAG = TALK ADDRESS GROUP
	MTA = MY TALK ADDRESS
	UNT = UNTALK

Table D-5 (continued)
IEEE command groups

OTA = OTHER TALK ADDRESS

ADDRESSED COMMAND GROUP

ACG = ADDRESSED COMMAND GROUP
GTL = GO TO LOCAL
SDC = SELECTIVE DEVICE CLEAR

STATUS COMMAND GROUP

RQS = REQUEST SERVICE
SRQ = SERIAL POLL REQUEST
STB = STATUS BYTE
EOI = END

E

IEEE-488 Conformance Information

Information

The IEEE-488.2 standard requires specific information about how the Model 7001 implements the standard. Paragraph 4.9 of the IEEE-488.2 standard (Std 488.2-1987) lists the documentation requirements. Table E-1 provides a summary of the requirements, and provides the information or references the manual for that information.

Table E-1
IEEE-488 documentation requirements

	Requirement	Description or Reference
(1)	IEEE-488 Interface Function Codes.	See Appendix C
(2)	Behavior of 7001 when the address is set outside the range 0-30.	Error message occurs. Previous address is retained.
(3)	Behavior of 7001 when valid address is entered.	No error message. Display returns to GPIB SETUP MENU.
(4)	Power-On Setup Conditions.	*RST; see paragraph 5.9.10. :SYST:PRES and :SYST:POS; see paragraph 5.10.7.
(5)	Message Exchange Options:	
(a)	Input buffer size.	256 bytes.
(b)	Queries that return more than one response message.	None.
(c)	Queries that generate a response when parsed.	All queries (Common Commands and SCPI).
(d)	Queries that generate a response when read.	None.
(e)	Coupled commands.	:TRIG:COUNT is coupled to :TRIG:COUNT:AUTO. Enabling Auto sets count to the scan list length.
(6)	Functional elements required for SCPI commands.	Contained in SCPI command subsystems tables (see Appendix B).
(7)	Buffer size limitations for block data.	Up to 20 characters for block display messages.

Table E-1 (continued)
IEEE-488 documentation requirements

(8)	Syntax restrictions.	Contained in paragraph 5.10 (SCPI Command Subsystems).
(9)	Response syntax for every query command.	Contained in paragraphs 5.9 (Common Commands) and 5.10 (SCPI Command Subsystems).
(10)	Device-to-device message transfer that does not follow rules of the standard.	None.
(11)	Block data response size.	None.
(12)	Common Commands implemented by 7001.	See Appendix A
(13)	Calibration query information.	Not applicable.
(14)	Trigger macro for *DDT.	Not applicable.
(15)	Macro information.	Not applicable.
(16)	Response to *IDN (identification).	See paragraph 5.9.5.

Table E-1 (continued)
IEEE-488 documentation requirements

(17)	Storage area for *PUD and *PUD?	Not applicable.
(18)	Resource description for *RDT and *RDT?	Not applicable.
(19)	Effects of *RST, *RCL and *SAV.	*RST; see paragraph 5.9.10, *RCL; see paragraph 5.9.9, *SAV; see paragraph 5.9.11.
(20)	*TST information.	See Section 7.
(21)	Status register structure.	See paragraph 5.6.
(22)	Sequential or overlapped commands.	All are sequential except :INIT and :INIT:CONT ON which are sequential.
(23)	Operation complete messages.	*OPC; see paragraph 5.9.6, *OPC?; see paragraph 5.9.7, *WAI; see paragraph 5.9.17.

F

SCPI Conformance Information

Introduction

The Model 7001 complies with SCPI version 1991.0.

Table F-1
Syntax of SCPI confirmed commands implemented by Model 7001

Command	Description
:DISPlay	
[:WINDow[1]]	Path to locate message to top portion of display
:TEXT	Path to control user text messages:
:DATA <a>	Define ASCII message "a" using up to 20 characters.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message.
:STATe?	Request message status (enabled or disabled).
:WINDow2	Path to locate message to bottom portion of display:
:TEXT	Path to control user text messages:
:DATA <a>	Define ASCII message "a" using up to 32 characters.
:STATe <b>	Enable (1 or ON) or disable (0 or OFF) message.
:STATe?	Request message status (enabled or disabled).
[:ROUTe]	
:CLOSe <list>	Path and command to close specified channels:
:STATe?	Request channels that are closed.
:OPEN <list> | ALL	Open specified (or all) channels.
:SCAN <list>	Path and command to specify channel list:
:POINts?	Request number of channels in the scan list.

Table F-1 (continued)
Syntax of SCPI confirmed commands implemented by Model 7001

Command	Description
:STATus	
:OPERation	Path to control operation event registers:
[:EVENt]?	Read the status register.
:CONDition?	Read the condition register.
:PTRansition <n>	Program the positive transition register (0 to 1122).
:PTRansition?	Read the positive transition register.
:NTRansition <n>	Program the negative transition register (0 to 1122).
:NTRansition?	Read the negative transition register.
:ENABle <n>	Program the enable register (0 to 1122).
:ENABle?	Read the enable register.
:ARM	Path to control arm event registers:
[:EVENt]?	Read the status register.
:CONDition?	Read the condition register.
:PTRansition <n>	Program the positive transition register (0 or 2).
:PTRansition?	Read the positive transition register.
:NTRansition <n>	Program the negative transition register (0 or 2).
:NTRansition?	Read the negative transition register.
:ENABle <n>	Program the enable register (0 or 2).
:ENABle?	Read the enable register.
:SEQuence	Path to control the sequence event registers:
[:EVENt]?	Read the status register.
:CONDition?	Read the condition register.
:PTRansition <n>	Program the positive transition register (0 to 6).
:PTRansition?	Read the positive transition register.
:NTRansition <n>	Program the negative transition register (0 to 6).
:NTRansition?	Read the negative transition register.
:ENABle <n>	Program the enable register (0 to 6).
:ENABle?	Read the enable register.
:TRIGger	Path to control trigger event registers:
[:EVENt]?	Read the status register.
:CONDition?	Read the condition register.
:PTRansition <n>	Program the positive transition register (0 or 2).
:PTRansition?	Read the positive transition register.
:NTRansition <n>	Program the negative transition register (0 or 2).
:NTRansition?	Read the negative transition register.
:ENABle <n>	Program the enable register (0 or 2).
:ENABle?	Read the enable register.
:PRESet	Return status registers to default states.
:QUEue	Path to access error queue:
[:NEXT]?	Request most recent error message.
:ENABle <list>	Specify error and status messages for queue.

Table F-1 (continued)
Syntax of SCPI confirmed commands implemented by Model 7001

Command	Description
:STATus	
:QUEStionable	Path to control questionable event registers:
[:EVENt]?	Read the status register.
:CONDition?	Read the condition register.
:PTRansition <n>	Program the positive transition register.
:PTRansition?	Read the positive transition register.
:NTRansition <n>	Program the negative transition register.
:NTRansition?	Read the negative transition register.
:ENABle <n>	Program the enable register.
:ENABle?	Read the enable register.
:SYSTem	
:ERRor?	Request message from Error/Status Queue.
:PRESet	Return instrument to default conditions.
:VERSion?	Request the revision level of the SCPI Standard.
Trigger commands	
:INITiate	Subsystem command path:
[:IMMediate]	Initiate one trigger (scan) cycle.
:CONTinuous <b>	Enable (1 or ON) or disable (0 or OFF) continuous initiation of trigger system.
:ABORt	Reset trigger system and go to idle state.
:ARM[:SEQuence[1]]	Subsystem command path to configure scan:
[:LAYer[1]]	Path to program arm layer of scan:
:IMMediate	Loop around control source.
:COUNt <n> | INFinite	Program number of arms (1 to 9999, or INFinite).
:COUNt?	Request programmed arm count.
:SOURce HOLD | IMMediate | MANual | BUS | EXTernal	Select Arm Layer 1 control source.
:SOURce?	Request programmed source (event).
:SIGNal	Loop around control source.
:LAYer2	Path to program scan layer of scan:
:IMMediate	Loop around control source.
:COUNt <n> | INFinite	Program number of scans (1 to 9999, or INFinite).
:COUNt?	Request programmed scan count.
:DELay <num>	Program delay (0 to 99999.999 sec)
:DELay?	Request programmed delay period.
:SOURce HOLD | IMMediate | MANual | BUS | EXTernal | TIMer	Select Arm Layer 2 control source.
:SOURce?	Request programmed source (event).
:SIGNal	Bypass scan control source one time only.
:TIMer <num>	Set timer interval (0 to 99999.999 sec).
:TIMer?	Request the programmed timer interval.

Table F-1 (continued)
Syntax of SCPI confirmed commands implemented by Model 7001

Command	Description
Trigger commands	
:TRIGger[:SEQuence[1]]	Path to program channel layer of scan:
:IMMediate	Scan channels immediately. (Loop around control source.)
:COUNt <n> | INFinite	Program number of channels (1 to 9999, or INFinite).
:AUTo ON/OFF	Use scan-list-length.
:COUNt?	Request programmed channel count.
:DELay <num>	Program delay (0 to 99999.999 sec)
:DELay?	Request programmed delay period.
:SOURce HOLD | IMMediate | MANual | BUS | EXTernal | TIMer	Select Trigger Layer Control Source.
:SOURce?	Request programmed source (event).
:SIGNal	Bypass channel control source one time only.
:TIMer <num>	Set timer interval (0 to 99999.999 sec).
:TIMer?	Request the programmed timer interval.

Table F-2
Syntax of non-SCPI commands implemented by Model 7001

Command	**Description**
:DISPlay	
:SMESsage <b>	Enable (1 or ON) or disable (0 or OFF) displayed status messages.
:SMESsage?	Request state of status message display.
:OUTPut	
:TTLn	Path and command to specify output line "n" (1-4):
:LSENse AHIGh | ALOW	Set polarity; active high (AHIG) or active low (ALOW).
:LSENse?	Request polarity of specified output line (n).
[:ROUTe]	
:SCAN?	Request the programmed scan list.
:FCHannels <list>	Specifies channels that cannot be closed (forbidden).
:FCHannels?	Request list of restricted channels.
:CONFigure	Configuration command path:
:SCHannel <b>	Enable (1 or ON) or disable (0 or OFF) Single Channel.
:SCHannel?	Request status of Single Channel mode.
:CPAir <b>	Enable (1 or ON) or disable (0 or OFF) Channel Pairing.
:CPAir?	Request status of Channel Pairing.
:SLOT1	Path to configure CARD 1:
:CTYPE <type>	Specify the card type installed in the slot.
:CTYPE?	Request the card type installed in the slot.
:POLE <n>	Select pole mode (1, 2 or 4).
:POLE?	Request the programmed number of poles.
:STIMe <num>	Set relay settling time in seconds (0 to 99999.999).
:STIMe?	Request the programmed relay settling time.
:SLOT2	Path to configure CARD 2:
:CTYPE <type>	Specify the card type installed in the slot.
:CTYPE?	Request the card type installed in the slot.
:POLE <n>	Select pole mode (1, 2 or 4).
:POLE?	Request the programmed number of poles.
:STIMe <num>	Set relay settling time in seconds (0 to 99999.999).
:STIMe?	Request the programmed relay settling time.
:MEMory	Path to program memory:
:SAVe M<num>	Saves channel pattern at memory location (1-100).
:RECall M<num>	Recalls channel pattern from memory location (1-100).
:SENSe[1]	
:TTL1	Command path for input port.
:DATA?	Read digital input port.
:SENSe2	Command path:
:DATA? <list>	Read specified input channels for slot 1.
:SENSe3	Command path:
:DATA? <list>	Read specified input channels for slot 2.

Table F-2 (continued)
Syntax of non-SCPI commands implemented by Model 7001

Command	Description
:SOURce	Command path to program digital output port bits:
:TTL1	Path to program Bit 1 of output port:
[:LEVel] <b>	Set (1 or ON) or reset (0 or off).
[:LEVel]?	Request status of Bit 1.
:TTL2	Path to program Bit 2 of output port:
[:LEVel] <b>	Set (1 or ON) or reset (0 or off).
[:LEVel]?	Request status of Bit 2.
:TTL3	Path to program Bit 3 of output port:
[:LEVel] <b>	Set (1 or ON) or reset (0 or off).
[:LEVel]?	Request status of Bit 3.
:TTL4	Path to program Bit 4 of output port:
[:LEVel] <b>	Set (1 or ON) or reset (0 or off).
[:LEVel]?	Request status of Bit 4.
:SYSTem	
:POSetup RST | PRESet | SAV0 | SAV1 | SAV2 | SAV3 | SAV4 | SAV5 | SAV6 | SAV7 | SAV8 | SAV9	Select Power-on setup.
:POSetup?	Request Power-on setup.
Trigger commands:	
:ARM[:SEQuence[1]]	Subsystem command path to configure scan:
[:LAYer[1]]	Path to program arm layer of scan:
:SOURce TLINk	Select Arm Layer 1 control source.
:TCONfigure	Path to configure Triggers.
:DIRection SOURce | ACCeptor	Enable (SOUR) or disable (ACC) Bypass.
:DIRection?	Request the programmed direction.
:ASYNchronous	Path to configure asynchronous Trigger Link mode:
:ILINe <n>	Select input line (1 to 6).
:ILINe?	Request programmed input line.
:OLINe <n>	Select output line (1 to 6).
:OLINe?	Request programmed output line.
LAYer2	Path to program scan layer of scan.
:SOURce TLINk	Select Arm Layer 2 control source.
:TCONfigure	Path to configure Trigger Link:
:DIRection SOURce | ACCeptor	Enable (SOUR) or disable (ACC) Bypass.
:DIRection?	Request the programmed direction.
:ASYNchronous	Path to configure asynchronous mode:
:ILINe <n>	Select input line (1 to 6).
:ILINe?	Request programmed input line.
:OLINe <n>	Select output line (1 to 6).
:OLINe?	Request programmed output line.

Table F-2 (continued)
Syntax of non-SCPI commands implemented by Model 7001

Command	Description
Trigger commands:	
:TRIGger[:SEQuence[1]]	Path to program channel layer of scan.
:SOURceTLINk	Select Trigger Layer Control Source.
:TCONfigure	Path to configure Triggers:
:PROTocol ASYNchronous | SSYNchronous	Select protocol (asynchronous or semi-synchronous Trigger Link.)
:PROTocol?	Request programmed protocol.
:DIRection SOURce | ACCeptor	Enable (SOUR) or disable (ACC) Bypass.
:DIRection?	Request the programmed direction.
:ASYNchronous	Path to configure asynchronous Trigger Link mode:
:ILINe <n>	Select input line (1 to 6).
:ILINe?	Request programmed input line.
:OLINe <n>	Select output line (1 to 6).
:OLINe?	Request programmed output line.
:SSYNchronous	Path to configure semi-synchronous Trigger Link mode:
:LINe <n>	Select trigger line (1 to 6).
:LINe?	Request programmed trigger line.

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*ESE? — event status enable query 5-42
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Service Form

Model No. ____________________ **Serial No.** ____________________ **Date** ____________

Name and Telephone No. ____

Company ____

List all control settings, describe problem and check boxes that apply to problem. ______________________

____

____

☐ Intermittent

☐ IEEE failure

☐ Front panel operational

☐ Analog output follows display

☐ Obvious problem on power-up

☐ All ranges or functions are bad

☐ Particular range or function bad; specify ______________________

☐ Batteries and fuses are OK

☐ Checked all cables

Display or output (check one)

☐ Drifts

☐ Unstable

☐ Overload

☐ Unable to zero

☐ Will not read applied input

☐ Calibration only

☐ Data required

☐ Certificate of calibration required

(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

____

____

What power line voltage is used? ____________________ Ambient temperature? ____________________°F

Relative humidity? ____________________ Other? ______________________________

Any additional information. (If special modifications have been made by the user, please describe.)

____

____

Be sure to include your name and phone number on this service form.

KEITHLEY

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